Evaluation of Management of Water Releases for Painted Rocks Reservoir, Bitterroot River, Montana

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EVALUATION OF MANAGEMENT OF WATER RELEASES FOR PAINTED ROCKS RESERVOIR, BITTERROOT RIVER, MONTANA

Annual Progress Report FY1985

By

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EXECUTIVE SUMMARY

This study was initiated in July, 1983 to develop an implementable water management plan for the release of purchased water from Painted Rocks Reservoir which would provide optimum benefits to the river and to gather fisheries and habitat information which would evaluate the effectiveness of these supplemental releases in improving trout populations in the Bitterroot River. The study is part of the Northwest Power Planning Council's Fish and Wildlife Program and is funded by the Bonneville Power Administration. This annual report presents data collected during the 1985 field season and makes comparisons with data collected in 1983 and 1984.

Approximately 15,000 AF of supplemental reservoir water was released annually into the Bitterroot River during the 1983, 1984, and 1985 irrigation seasons. Flows within the dewatered reach were maintained near target levels during 1983 and 1984. During 1985, supplemental releases were insufficient to maintain minimum flow recommendations. About 34% of the main stem of river was dewatered to some extent in the 1985 irrigation season. Discharge was less than 2.83 m^3/sec (100 ft^3/sec) for a 20-day period and was less than 1.42 m^3/sec (50 ft^3/sec) for a 13-day period. During peak irrigation, withdrawals by diversion were estimated to total 24.10 m^3/sec (850 ft^3/sec). Groundwater seepage and returns from irrigation appeared to provide flows to downstream irrigators and tended to lessen the effects of dewatering.

Supplemental releases made in 1985 were not reaching the dewatered section because of extensive diking on the river and the resultant appropriation of water into the irrigation systems. Approximately 99% of a 721 AF test spill was lost due to diversion or to natural phenomenon before reaching a gauging station located 105 km (65 mi) downstream. About 57% of this loss was attributable to appropriation into the ditch systems.

All usable storage in Painted Rocks Reservoir (31,706 AF) was drained during 1985 to meet base flow obligations and to provide for the release of purchased water. This excessive drawdown was due primarily to the drought conditions of 1985. Total inflow into the reservoir was estimated to average 2.80 m^3/sec (99 ft^3/sec) during July and 1.90 m^3/sec (67 ft^3/sec) during August. These rates were substantially less than historic median values.

Daily maximum water temperatures for four stations located in a downstream progression averaged 10.6, 11.9, 12.8 and 12.7 C for March through November. Daily temperature fluctuations at these stations averaged 3.5, 3.6, 3.4 and 1.8 C. Water temperature in the dewatered section of river appeared to be moderated by cooler groundwater seepage. The maximum water temperature recorded during 1985 was 23.4 C (74 F). Water temperatures in the Bitterroot River appeared to be adequate for trout viability.

Rainbow trout, brown trout and mountain whitefish were the predominant gamefish in the river. Rainbow trout numbers in a control section have increased from 511/mile in 1982 to 1256/mile in 1985. In a dewatered section, rainbow trout numbers have increased from 182/mile in 1983 to 432/mile in 1985. In a section rewatered by irrigation returns, rainbow trout numbered 323/mile during 1985. Brown trout numbers in the control section have not significantly changed between 1982 and 1985. Numbers have ranged from 225/mile to 296/mile during the four years of study. In the dewatered section, brown trout numbers have increased from 223/mile in 1983 to 361/mile in 1985. In the section rewatered by irrigation returns, too few brown trout were collected in 1985 to obtain an estimate.

Supplemental releases of reservoir water appeared to be enhancing the rainbow trout population in the control section. The potential for enhancement of trout populations in the dewatered section appeared to be reduced due to the appropriation of supplemental water into the irrigation systems. The severe dewatering in 1985 did not seem to adversely effect adult trout populations in the Bitterroot River. Poor recruitment of young of the year fish into the population as a result of flow depletions probably was responsible for the suppressed numbers of rainbow trout that were found in the dewatered section.

Instream flow recommendations obtained from wetted perimeter-discharge relationships averaged 11.35 m^3/sec (400 ft^3/sec) for the dewatered section and 8.50 m^3/sec (300 ft^3/sec) for the section rewatered by irrigation returns. A flow of 4.25 m^3/sec (150 ft^3/sec) provided the minimum depth and width criteria needed to float drift boats or rafts over the shallow riffle areas in both sections of the river.

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INTRODUCTION

The Bitterroot River, located in western Montana, is an important and heavily used resource, providing water for agriculture and a source for diversified forms of recreation. Water shortages in the river, however, have been a persistent problem for both irrigators and recreational users. Five major diversions and numerous smaller canals remove substantial quantities of water from the river during the irrigation season. Historically, the river has been severely dewatered between the towns of Hamilton and Stevensville as a result of these withdrawals.

Demands for irrigation water from the Bitterroot River have often conflicted with the instream flow needs for trout. Withdrawals of water can decrease suitable depths, velocities, substrates and cover utilized by trout (Stalnaker and Arnette 1976, Wesche 1976). Losses in habitat associated with dewatering have been shown to diminish the carrying capacities for trout populations (Nelson 1980). Additionally, dewatering of the Bitterroot River has forced irrigators to dike or channelize the streambed to obtain needed flows. These alterations reduce aquatic habitat and degrade channel stability. Odell (personal communication) found a substantial reduction in the total biomass of aquatic insects within a section of the Bitterroot River that had been bulldozed for irrigation purposes.

The Montana Department of Fish, Wildlife and Parks (MDFWP) has submitted a proposal to the Northwest Power Planning Council for the purchase of 10,000 acre-feet (AF) of stored water in Painted Rocks Reservoir to augment low summer flows in the Bitterroot River. This supplemental water potentially would enhance the fishery in the river and reduce degradation of the channel due to diversion activities.

The present study was undertaken to: (1) develop an implementable water management plan for supplemental releases from Painted Rocks Reservoir which would provide optimum benefits to the river; (2) gather fisheries and habitat information to evaluate the effects of dewatering in the river; (3) obtain baseline information that would aid in determining the effectiveness of supplemental water releases in improving the fisheries resource. The study was initiated in July 1983.

DESCRIPTION OF STUDY AREA

The Bitterroot River is located in Ravalli and Missoula Counties in west central Montana (Figure 1). It originates at the confluence of the East Fork and West Fork of the Bitterroot River near the town of Conner and flows northerly for approximately 135 km (84 mi) to its confluence with the Clark Fork River at Missoula. The elevation of the river ranges from 1,222 m (4,010 ft) near Conner to 942 m (3,090 ft) at Missoula. The gradient of the river averages about 3.22% (17 ft/mi) near Darby and about 0.57% (3 ft/mi) near Missoula (Figure 2). The basin drains approximately 725,212 hectares (2,800 mi^2).

From Conner to Sleeping Child Creek, the Bitterroot River flows through a relatively narrow mountain valley. Downstream from Sleeping Child Creek, the river bottom broadens into the farmlands of the Bitterroot Valley. A majority of the valley bottom consists of irrigated cropland or pastureland. However, substantial acreage of the valley has been divided into parcels of less than 40 acres. These parcels have been classified as "rural and suburban tracts" by the U.S. Department of Agriculture (1977). In association with these "suburban" tracts, the development of subdivisions is common throughout the valley.

The streambed of the Bitterroot River is typified by large bars of deposited gravel and an extensive network of side channels. The wide riparian zone is dominated by a cottonwood (<u>Populas spp.</u>)/Ponderosa Pine (<u>Pinus ponderosa</u>) overstory. Numerous developed and undeveloped recreational sites provide good access to the river.

The river valley is bordered on the west by the Bitterroot Mountains and on the east by the Sapphire Mountains. The Bitterroot Mountains receive up to 254 cm (100 in) of annual precipitation and the Sapphire Mountains receive up to 127 cm (50 in) of precipitation (Senger 1973). A majority of the mountain precipitation is snowfall. Numerous tributaries drain the bordering mountains and supply water for irrigation to the farmlands of the valley. The west-side streams exhibit greater seasonal fluctuations in flow than do the east-side streams (McMurtrey et al. 1972). Tributaries from the mountains add considerable flow to the Bitterroot River during spring runoff but many are diverted for irrigation and contribute little flow during the summer and early fall.

Painted Rocks Reservoir is located on the West Fork of the Bitterroot River approximately 36 km (22 mi) upstream from its confluence with the East Fork. The reservoir was completed in 1940 as a multi-purpose project and is operated by the Department of Natural Resources and Conservation (DNRC). The reservoir has a storage capacity of 32,362 acre-feet (AF) and a surface area at full pool of 265 hectares (Brown 1982). Elevation at the spillway

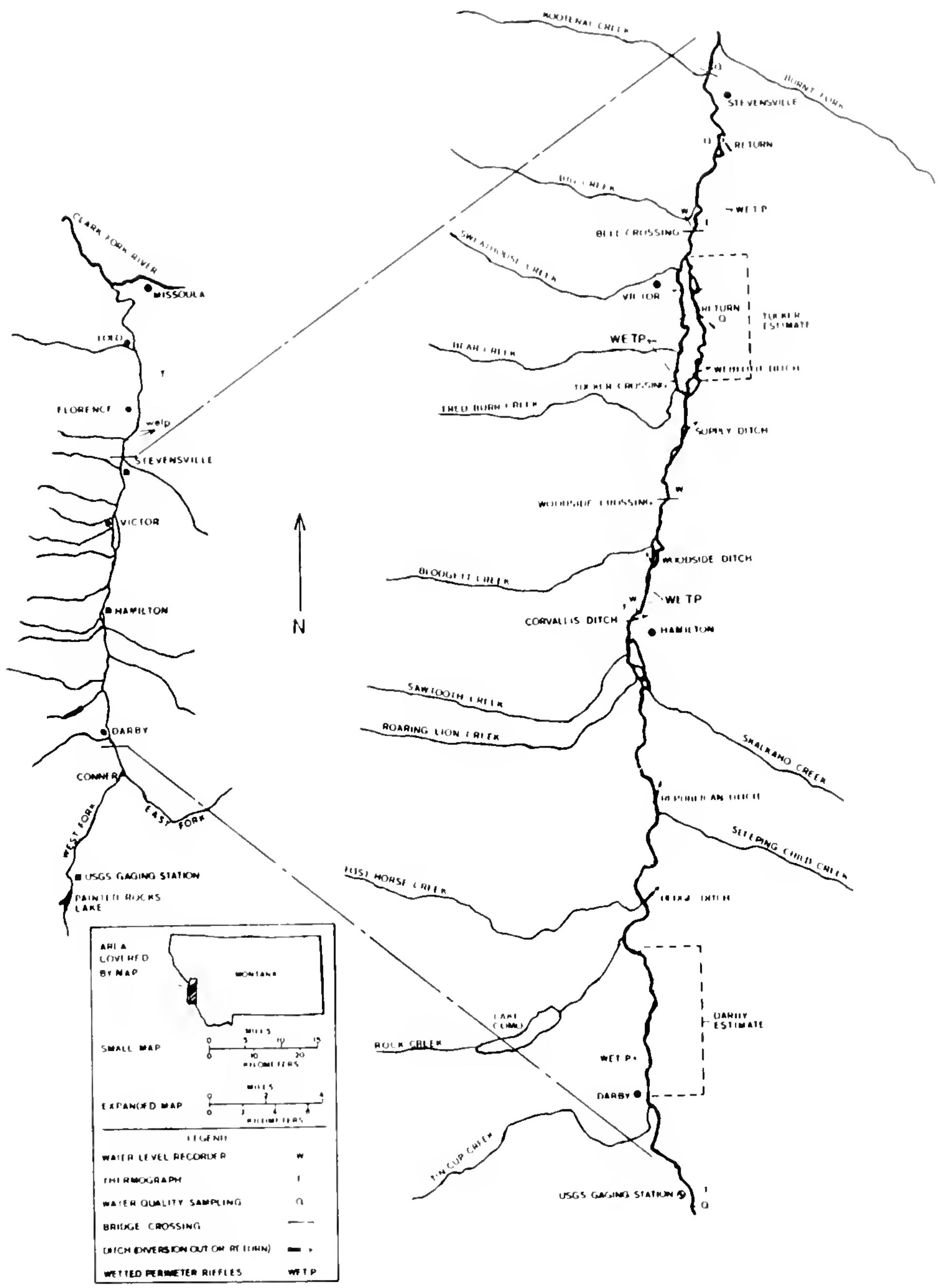

Figure 1. Map of the Bitterroot River showing locations of study sections.

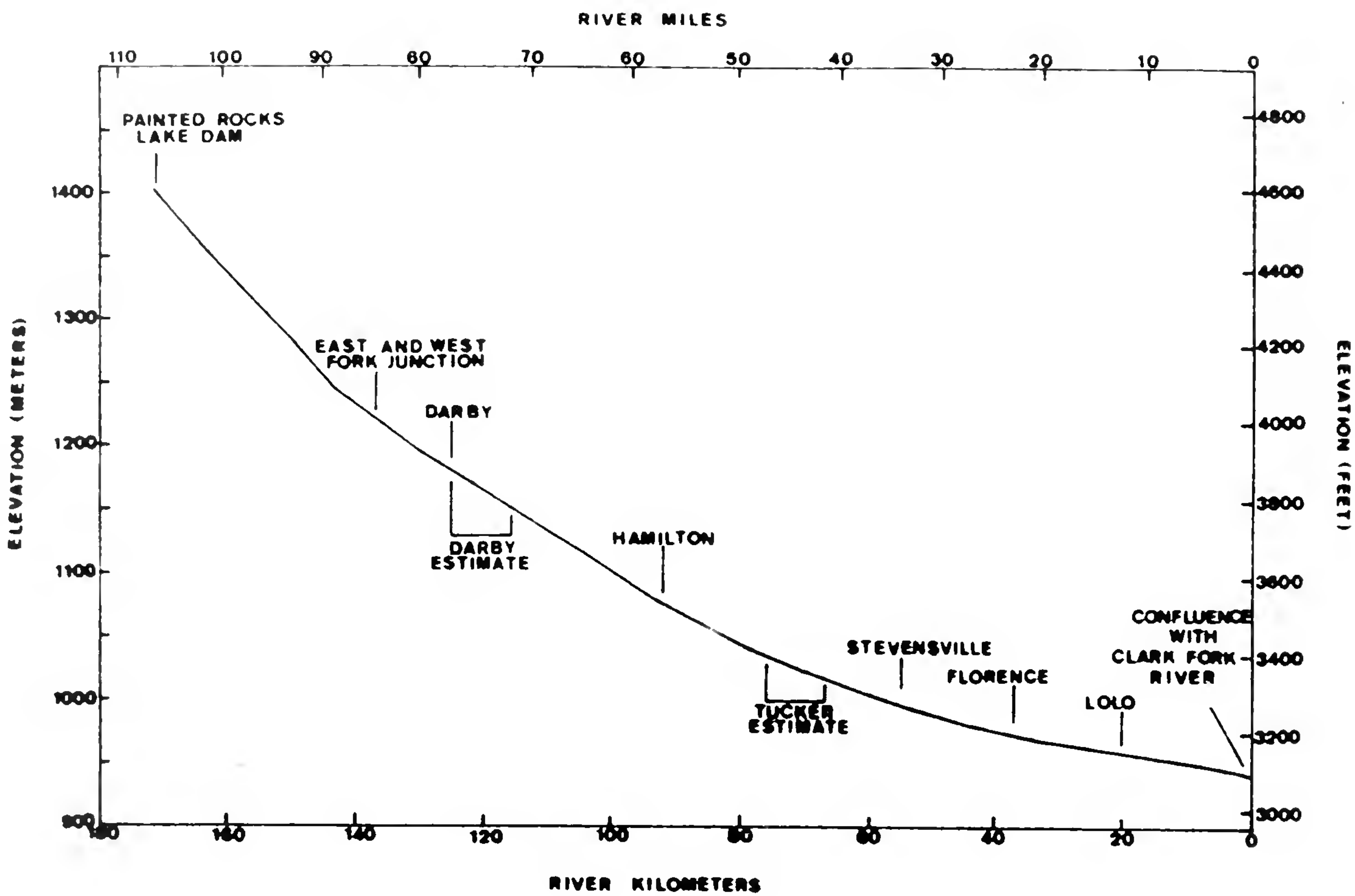

Figure 2. Longitudinal profile of the Bitterroot River from Painted Rocks Reservoir to the confluence with the Clark Fork River.

is 1,440 m (4,725 ft). As a matter of DNRC policy, flow released from the reservoir is maintained at 3.45 m^3 sec (125 ft^3/sec) during August through November and 2.83 m^3/sec (100 ft^3/sec) during December through July (DNRC 1980). These flow releases do not include spill from the reservoir during spring runoff.

Mean, minimum, and maximum discharges of the Bitterroot River measured near Darby over a 46-year period ending in 1983 were 26.4, 2.0 and 325.7 m^3/sec (931, 71, and 11,500 ft^3/sec), respectively (U.S.G.S. 1983). Annual flow of the river at Missoula averages approximately 64.8 m^3/sec (2,290 ft^3/sec). Characteristics of flow monitored at the U.S.G.S. stations established on the West Fork near Painted Rocks Reservoir, the East Fork near Conner and the main stem near Darby have been summarized by Brown(1982). Median values of average monthly flow recorded at these stations during July, August and September are given in Table 1. Flows in the Bitterroot River downstream from the gauging station near Darby vary greatly from reach to reach due to losses from irrigation withdrawals and to gains from tributary inflow and irrigation returns (Figure 1). Critical dewatering of the river commonly occurs in the reach located between Hamilton and Stevensville as a result of irrigation withdrawals.

Three study sections were established on the Bitterroot River for extensive investigation (Figure 1). The Darby section begins near the bridge at Darby and extends 9.36 km (5.82 mi) downstream to the Como bridge. This section remains well watered throughout the year and serves as a control.

The Tucker section begins at Tucker crossing and extends 8.92 km (5.54 mi) downstream to approximately 1.6 km (1 mi) upstream from Bell crossing. This section is characterized by two channels that become separated by as much as 1.6 km (1 mi). Because of differences in flow and habitat characteristics, each channel was treated as a distinct reach. The Tucker section was established within the reach of river that historically has become severely dewatered.

The Poker Joe section begins at the railroad trestle located upstream from the Poker Joe Fishing Access site and extends 8.41 km (5.23 mi) downstream to the Florence bridge. This section, located downstream of the dewatered reach, remains well watered throughout the year due to a major irrigation return located near Stevensville.

Table 1. Median values of average monthly flows recorded at stations on the upper Bitterroot River for July, August and September.

Month	West Fork		East Fork		Darby	
	m^3/sec	ft^3/sec	m^3/sec	ft^3/sec	m^3/sec	ft^3/sec
July	7.0	247	8.3	293	28.0	990
August	3.8	135	3.1	108	10.4	367
September	3.8	133	2.6	91	8.9	313

METHODS

Parameters of Discharge

Discharge in the River

Stage of the Bitterroot River was monitored using Belfort continuous water level recorders (5-FW series). Recorders were installed near Hamilton, Woodside crossing, Bell crossing and Poker Joe Fishing Access (Figure 1). At Hamilton, the recorder was mounted in an abandoned DNRC gauge house above a functional stilling well. The recorder at Woodside crossing was mounted on a 3-in (in diameter) standpipe that was fastened to a bridge abutment. At Bell crossing, the recorder was mounted on an observation well installed approximately 2.7 m (9.5 ft) from waters edge. This well was constructed by pounding a 3-in (in diameter) steel pipe about 4.5-6.0 m (15-20 ft) into the ground. Changes in groundwater levels at this site were known to be closely correlated with changes in river stage (Lere 1984). The recorder installed near the Poker Joe Fishing Access was mounted on a 3-in (in diameter) steel standpipe that had been pounded approximately 1.0 m (3.0 ft) into the streambed.

Eight day time scale gears were used to drive the charts for each recorder. The stage ratio gearing used in recorders at Hamilton and Bell crossing was 12.7 cm (5 in) of chart to 30.5 cm (12 in) of water. For recorders at Woodside crossing and Poker Joe, the stage ratio was 2.5 cm (1 in) of chart to 30.5 cm (12 in) of water.

Discharge of the river was measured using a Price AA current meter according to standard techniques of the U.S.G.S. (Corbette et al. 1943). Stage-discharge rating curves were developed for each gauging station. Rating curves were used to predict discharge for hourly stage recordings. Averages of 24 hourly recordings were computed to obtain mean daily discharge.

Withdrawals by Diversions

Belfort continuous water level recorders (5-FW series) were used to monitor flow in the Hedge, Corvallis, Supply and Webfoot diversions (Figure 1). The recorders were installed near the headgate of each ditch system. Recorders were mounted on 3-in (in diameter) steel standpipes that had been pounded approximately 1.0 m (3.0 ft) into the bed of the ditch.

Thirty-two day time scale gears were used to drive the charts for each recorder. The stage ratio gearing used in the recorders was 2.5 cm (1 in) of chart to 30.5 cm (12 in) of water.

Flow in each ditch was measured using a Price AA current meter according to standard U.S.G.S. techniques. Stage-discharge rating curves developed for each diversion were used to predict discharge for stage recordings taken every six hours. Averages of four recordings were computed to obtain mean daily discharge.

A staff gauge was used to monitor flow in the Republican diversion. This gauge, mounted on a steel fencepost, was located about 1 km downstream from the headgate. Stage readings were taken periodically and discharge was computed from a derived rating curve.

Test Releases

The release of water from Painted Rocks Reservoir was monitored using the U.S.G.S. station located on the West Fork of the Bitterroot River. The volume of supplemental water passing downstream gauging stations was quantified by computing the difference between hourly recorded discharge and discharge projected to occur if water had not been released. Projected flows were determined graphically from the hydrographs derived for each station. Incremental discharge values were converted to acre-feet and then summed to obtain the total volume of spill reaching each station. A similar approach was used to compute flow changes in the monitored diversions as a result of the test spill.

Reservoir Elevations

The elevation of the water level in Painted Rocks Reservoir was monitored biweekly using standard survey techniques. Water level elevations were established from a U.S.G.S. benchmark located on the dam.

Average monthly inflow into the reservoir was determined using the formula (Brown 1982):

$I = (V_1 - V_2) + R$ where
I = Total monthly inflow (AF),
V_1 = Month-end contents (AF),
V_2 = Previous month-end contents (AF) and
R = Total monthly outflow (AF).

Water Temperatures

Thirty-day continuous recording thermographs (Taylor models) were used to monitor water temperatures in the main stem of the Bitterroot River. Recorders were mounted in gauge houses at the U.S.G.S station near Darby and at the abandoned DNRC station at Hamilton (Figure 1). Two additional recorders were mounted in steel boxes at Bell crossing and at Maclay bridge. The thermocouple lead for each thermograph was extended through

plastic sewer pipe as far as possible into the river and anchored with rock. A maximum/minimum thermometer installed near the base of Painted Rocks Reservoir was used to monitor temperatures in the West Fork. Thermometer readings at this site were made biweekly.

Parameters of Trout Populations

Population Estimates

A mobile electrofishing system was used to sample trout populations in the Bitterroot River. A 4.0 m (13 ft) fiberglass boat with negative electrodes suspended from the gunwales was used to carry a portable 2,000-watt generator and a Coffelt (Model VVP-2E) rectifying unit. The positive electrode was hand held and attached with approximately 10 m (30 ft) of 14-gauge electrical cord.

Captured salmonids were classified by species, measured to the nearest 1.0 mm (total length) and weighed to the nearest 10 grams. Multiple marking and recapture runs were necessary to obtain adequate samples for population estimates. Fish were marked with a caudal fin punch. Samples of scales were taken for analyses of age and growth. All fish were released near their site of capture. During 1985, spring marking runs were completed on April 12 in the Tucker section and on April 23 in the Darby section. Fall marking runs were completed in the Darby, Tucker and Poker Joe sections on September 4, 13 and 25, respectively. Recapture runs were made approximately 2 weeks following marking runs.

Population estimates were made using Chapman's modification of Peterson's mark and recapture formula (Ricker 1975):

$$N = \frac{(M+1)(C+1)}{R+1} - 1 \text{ where}$$

N = Population estimate,
M = Number of fish marked,
C = Number of fish recaptured and
R = Number of marked fish in recapture sample.

A computer program developed by MDFWP was used to calculate estimates of populations, condition factors for fish over 12.6 cm (5 in) in total length and corresponding 80% confidence intervals. Estimates of numbers and biomass were computed by length and age groups. Condition factors were calculated using the formula (Carlander 1969):

$$K = \frac{10^5 W}{l^3} \text{ where}$$

K = condition factor,
W = total weight (gm) and
l = total length (mm).

Age and Growth

Scale samples were mounted on acetate slides and impressions were magnified 63x by a micro-fiche reader for aging. Scales were aged twice on different dates to verify precision. Repeatability of aging (precision) ranged from 78 to 93%. A majority of the error was associated with mis-aging older fish by one year.

The Monastyrsky method (Tesch 1971) was used to back-calculate lengths at age of fish:

$$\text{Predicted length} = K \times (\text{scale measurement})^{n}, \text{ where}$$

K = intercept on the ordinate and
n = slope of the relationship

The regression formula derived for rainbow trout captured during the fall, 1984 was:

$$\text{Predicted length} = 7.10855 \times (\text{scale measurement})^{0.8784}$$

$r^2 = 0.92$
Number of fish = 705

For brown trout:

$$\text{Predicted length} = 5.84627 \times (\text{scale measurement})^{0.9277}$$

$r^2 = 0.94$
Number of fish = 756

Instream Flow Recommendations

The wetted perimeter/inflection point methodology was used to quantify instream flow recommendations. In general, this technique derives wetted perimeter-discharge relationships at selected channel cross sections using a hydraulic simulation model. A graphical plotting of these relationships typically delineates an inflection point on the derived curve. At this point, the rate of loss of wetted perimeter greatly increases as discharge decreases. Nelson (1980) found standing crops of adult trout substantially decreased in years when flows were less than derived inflection points. A detailed description of the rationale and methodology for this technique has been given by Nelson (1984).

Two riffles located near Hamilton, two riffles located in the east channel of the Tucker section, two riffles located in the west channel of the Tucker section and three riffles located downstream from Stevensville were utilized for analysis of instream flows during 1985 (Figure 1). Wetted perimeter data were obtained from three channel cross sections established at

each riffle. A flow recommendation for a single riffle was computed by averaging the wetted perimeter data predicted for associated flows of interest obtained at the three cross sections. Inflection point values derived for all riffles within a section were averaged to obtain a final flow recommendation.

RESULTS AND DISCUSSION

Bitterroot River Discharge

Discharge in 1985

Discharge patterns in the Bitterroot River were monitored at two permanent (U.S.G.S) and four temporary gauging stations during 1985. The permanent stations are located on the West Fork near Painted Rocks Reservoir and on the main stem near Darby. Temporary stations were located at Hamilton, Woodside crossing, Bell crossing and Poker Joe Fishing Access (Figure 1).

Hydrographs of the Bitterroot River developed during 1985 are presented in Figures 3 and 4. Discharge patterns were characterized by progressively decreasing flows from late May through mid-July as runoff from snowmelt subsided. Following spring runoff, discharge substantially varied from station to station due to extensive irrigation withdrawals and to inflow from tributaries and irrigation returns. Minimum flow levels at main stem gauging stations were reached during late July. Beginning in August, increased precipitation raised flows in the river and flows again increased in mid September as precipitation continued and diversions were closed. In late September, flows began to decline to approximate winter levels as precipitation lessened.

Approximately 34% (47 km) of the main stem was dewatered to some extent during 1985 (Figure 5). Critical dewatering was confined to about 16% (23 km) of the main stem, located in the reach of river between Tucker crossing and Stevensville. Daily discharge at Bell crossing was less than 2.83 m^3/sec (100 ft^3/sec) for a 20-day period beginning July 14 and was less than 1.42 m^3/sec (50 ft^3/sec) for a 13-day period beginning July 20. Minimum daily flows recorded during 1985 at stations within the dewatered reach were 6.68, 6.29 and 0.68 m^3/sec (236, 222 and 24 ft^3/sec) for Hamilton, Woodside crossing and Bell crossing, respectively. Minimum flows recorded at Darby and Poker Joe, stations outside of the dewatered reach, were 8.35 and 8.95 m^3/sec (295 and 316 ft^3/sec), respectively.

Mean daily flows (24-hour averages) obtained from the Hamilton, Woodside, Bell and Poker Joe stations for June through November are given in Appendix A1. Rating curves and associated regression equations of stage-discharge relationships derived for the four stations are presented in Appendix A2.

Daily discharge at the U.S.G.S. station near Darby during 1985 was consistently less than the median historic values recorded for June and July (Figure 6). However, flows during August were greater than median values and flows during September were commonly greater than 20 percent exceedence levels (U.S.G.S. 1985).

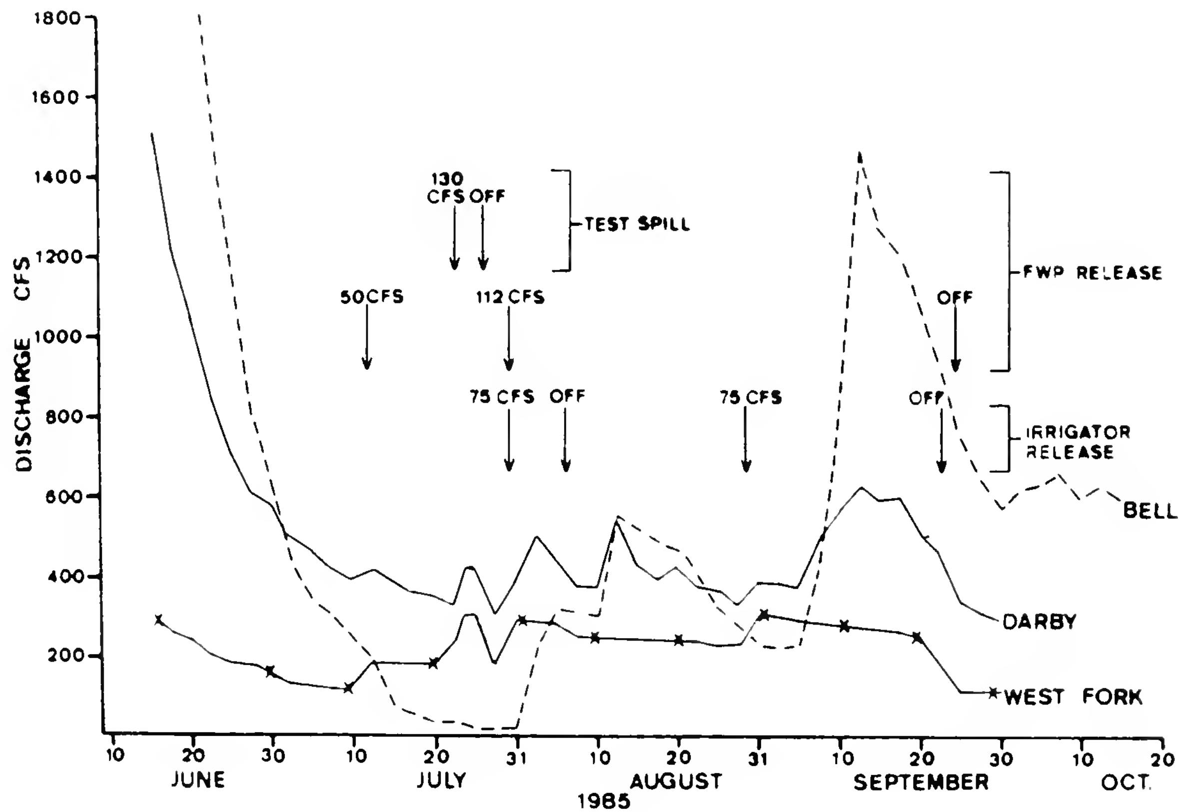

Figure 3. Hydrographs derived from the West Fork, Darby and Bell stations on the Bitterroot River during 1985 showing releases of supplemental water from Painted Rocks Reservoir.

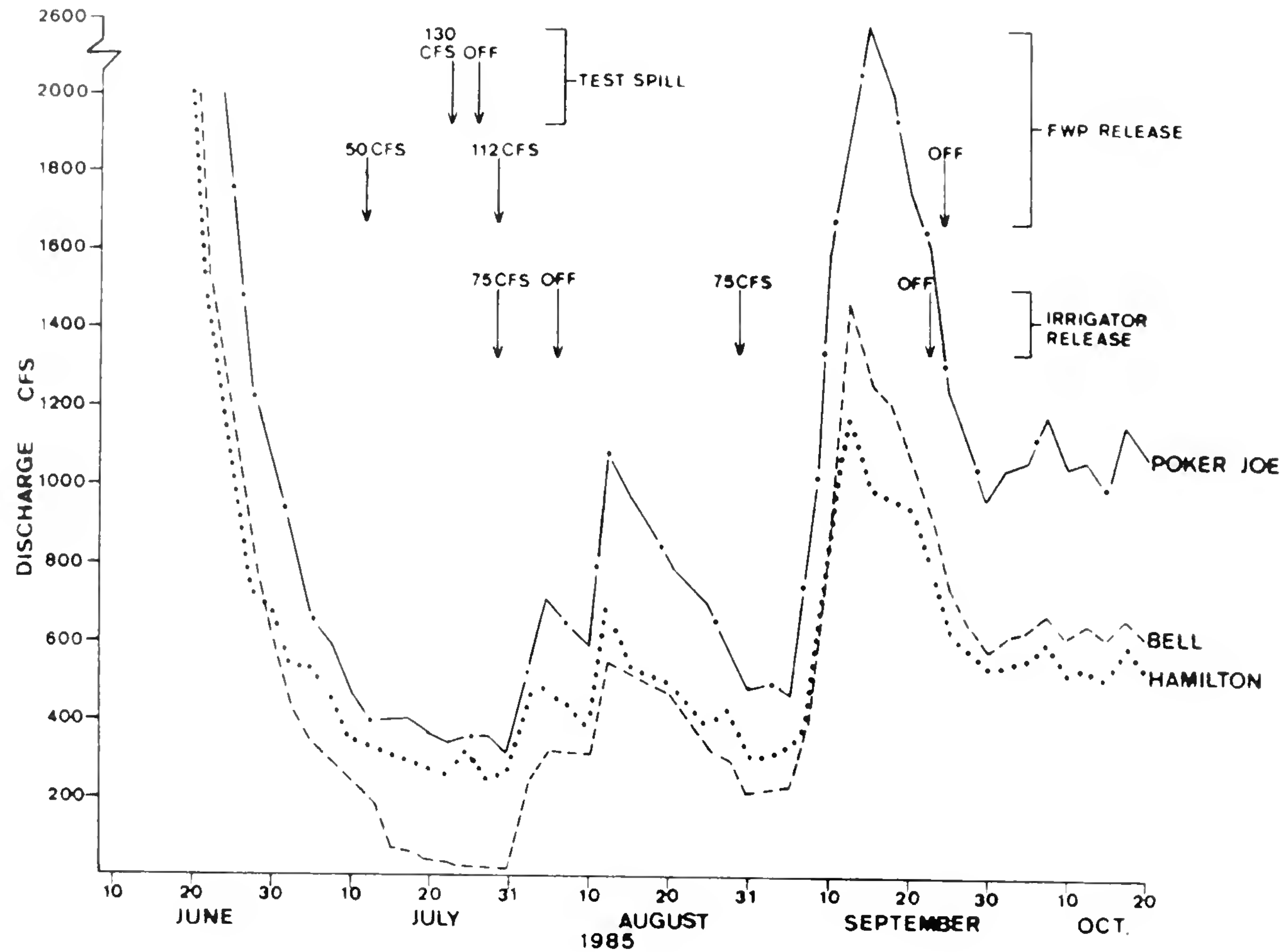

Figure 4. Hydrographs derived from the Hamilton, Bell and Poker Joe stations on the Bitterroot River during 1985 showing releases of supplemental water from Painted Rocks Reservoir.

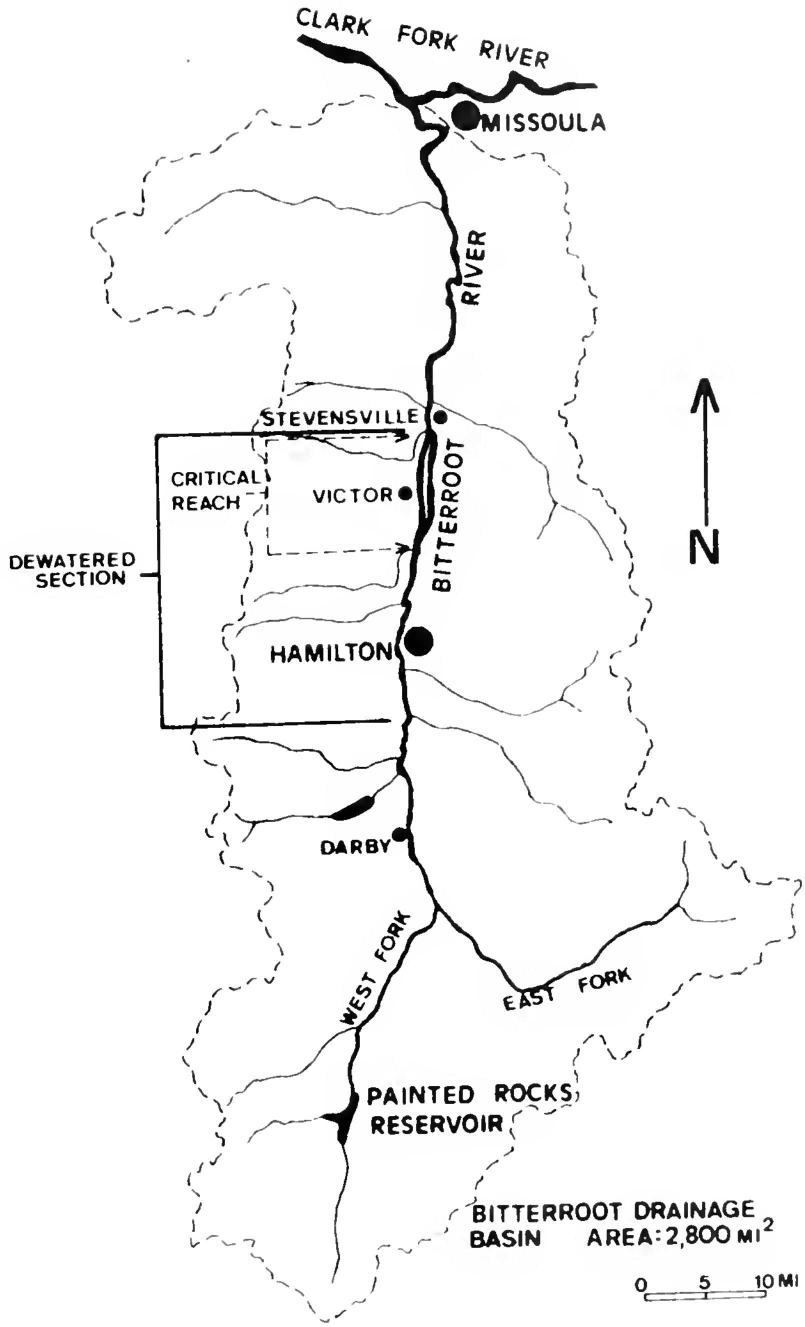

Figure 5. Map of the Bitterroot River showing the zones of dewatering.

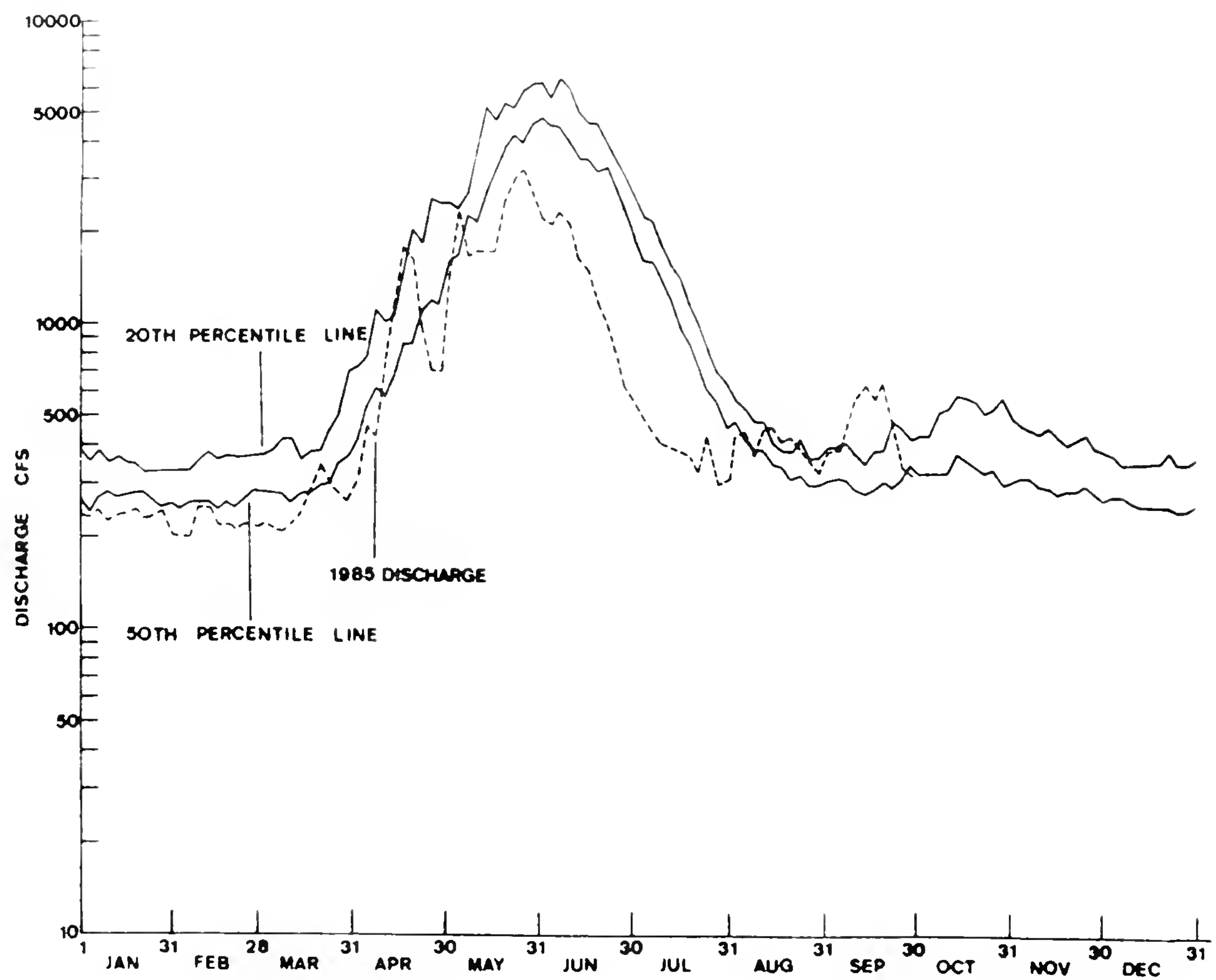

Figure 6. Comparison of 1985 flows to duration hydrographs derived for 20% and 50% exceedence values at the U.S.G.S. station near Darby.

Averages of monthly discharge recorded at main stem stations during 1983, 1984 and 1985 (years when supplemental water was released from Painted Rocks Reservoir) are compared in Table 2. July flows during 1985 were substantially less than those recorded during 1983 and 1984. In contrast, September flows during 1985 were similar to or greater than 1983 and 1984 flows.

The distribution of runoff in the Bitterroot River is greatly influenced by weather patterns. Extreme drought conditions during June and July contributed to the low level of flow in the river during 1985 (Table 3). Total precipitation for June and July at gauging stations in the valley was almost 5.1 cm (2 in) below normal (U.S. Department of Commerce 1985). In addition, snowpack in the basin as of May 1, 1985 (U.S. Department of Agriculture 1985) was only 78 percent of average (Table 4). During August and September, however, valley precipitation was 10.2 cm (4 in) greater than normal. This increased precipitation contributed to the greater than normal August and September flows during 1985.

Withdrawals by Diversions

Flows in the Hedge, Republican, Corvallis, Supply and Webfoot diversions were monitored during 1985 to assess the effects of irrigation withdrawal on discharge in the Bitterroot River (Figure 1). Hydrographs developed for these diversions are presented in Figures 7 and 8. Mean daily flows (data obtained on 6-hour basis) recorded during 1985 are given in Appendix A3. Stage-discharge relationships derived for the five diversions are presented in Appendix A4.

The five diversions, especially the Supply and Webfoot systems, exhibited extreme fluctuations in flow rates during the monitoring period. These fluctuations were due primarily to headgate adjustments and/or channel alterations. The chronologies for these management operations are given in Appendix A5. Diversion headgates were opened during late May or early April to begin irrigating crops. Closures of systems at the end of the irrigation season varied from early August for the Supply diversion to mid September for the Hedge and Republican diversions. The Corvallis, Supply and Webfoot diversions remained partially opened through the monitoring period.

Average monthly discharge obtained for each diversion during the monitoring period is presented in Table 5. Withdrawals during May through September averaged 2.75, 3.77, 1.84, 3.34 and 3.65 m^3/sec (97, 133, 65, 118 and 129 ft^3/sec) for the Hedge, Republican, Corvallis, Supply and Webfoot diversions, respectively. Withdrawals by the Republican diversion during May and June and withdrawals by the Webfoot diversion during May, June and July exceeded their respective decrees. The Hedge, Corvallis and Supply diversions were maintained for a majority of the monitoring period at levels below their respective decrees.

Table 2. Mean monthly flows (ft^3/sec) recorded at the Darby, Hamilton, Woodside, Bell and Poker Joe stations on the Bitterroot River during 1983, 1984 and 1985.

Month	Year	Darby[1]	Hamilton	Woodside	Bell	Poker Joe
July	1983	1021	--	--	1126[p]	--
	1984	1492	--	--	1727[p]	--
	1985	398	350	356	164	477
August	1983	486	--	--	528[p]	--
	1984	525	464[p]	518	432	--
	1985	409	440	435	355	700
September	1983	426	--	535[p]	486	--
	1984	504	795	794	781	--
	1985	458	704	662[p]	786	1312
October	1983	438	--	758	763	--
	1984	349	591	631	623	--
	1985	--	607	707	690	1174
November	1983	355	--	781[p]	845[p]	--
	1984	295	452[p]	539[p]	520[p]	--
	1985	--	662[p]	895[p]	738[p]	1276[p]

1 U.S.G.S. (1983, 1984, 1985).
p Summary is for an incomplete month.

Table 3. Monthly precipitation (inches) averaged for 3 stations[1] located in the Bitterroot Valley during the summers of 1983, 1984 and 1985.

Year	June		July		August		September		TOTAL June-September	
	Mean	Departure[2]	Mean	Departure[2]	Mean	Departure[2]	Mean	Departure[2]	Mean	Departure[2]
1983	1.37	-0.36	2.23	+1.45	2.51	+1.62	1.98	+0.92	8.09	+3.63
1984	1.84	+0.11	0.60	-0.18	1.89	+1.00	1.51	+0.45	5.84	+1.38
1985	0.38	-1.35	0.16	-0.62	2.70	+1.81	3.25	+2.19	6.49	+2.03

1 The 3 stations are located at Darby, Hamilton and Stevensville (U.S. Department of Commerce 1983, 1984, 1985).

2 Departure from normal

Table 4. Mean snowpack as of May 1 for 10 stations in the Bitteroot basin during 1983, 1984 and 1985.

Year	Mean Snowpack[1]	Percent of historic mean
1983	19.05	76
1984	22.52	90
1985	19.63	78

1 Mean water content in inches from 10 survey stations (U.S. Department of Agriculture 1983, 1984, 1985)

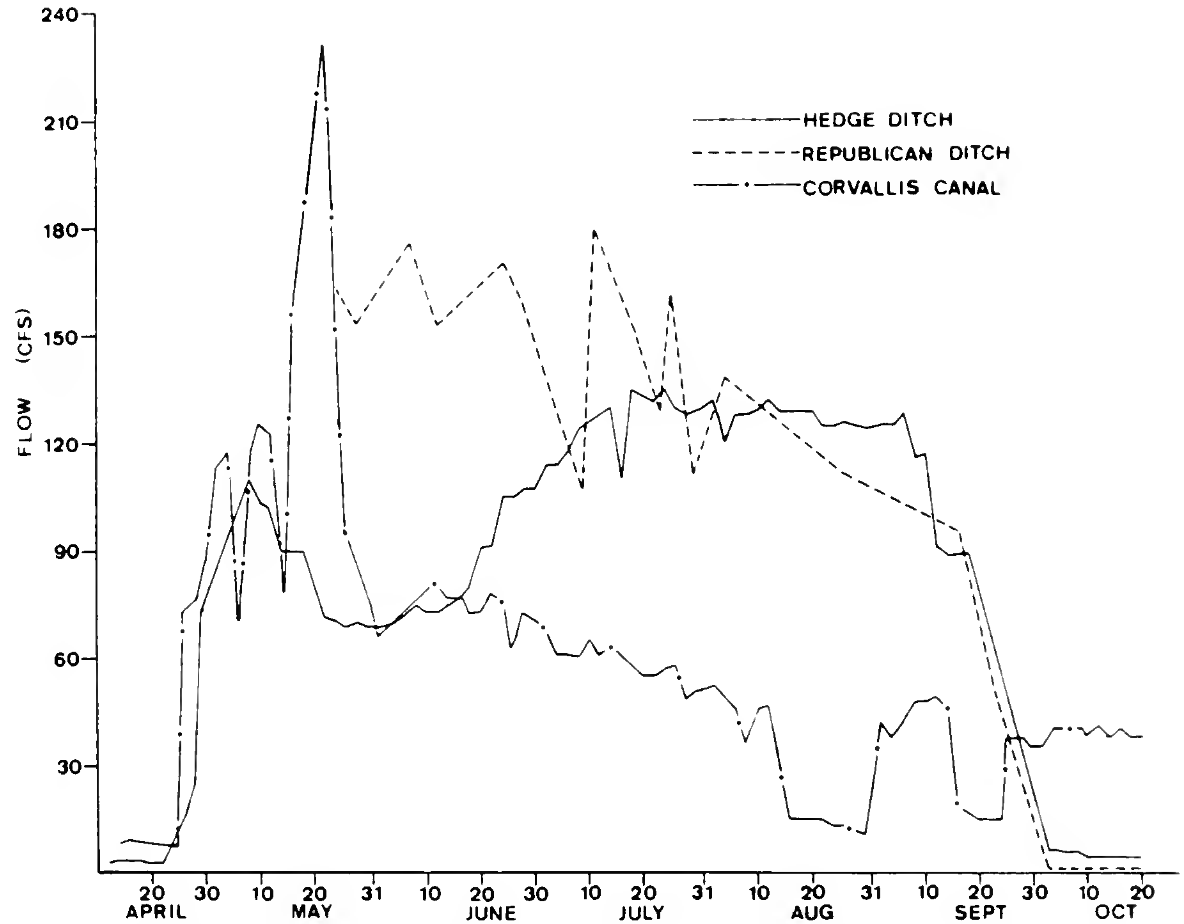

Figure 7. Hydrographs derived from gauging stations on the Hedge, Republican, and Corvallis diversions during 1985.

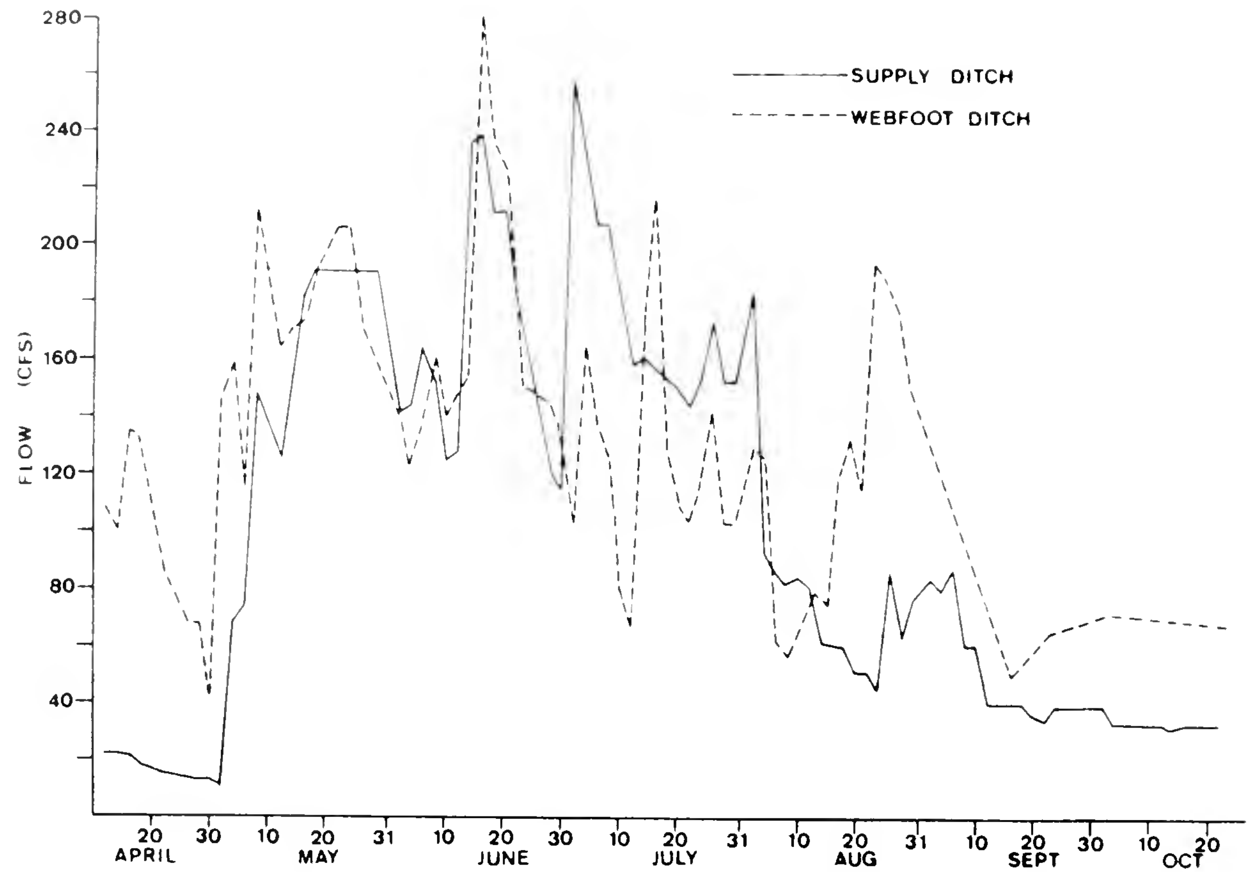

Figure 8. Hydrographs derived from gauging stations on the Supply and Webfoot diversions during 1985.

Table 5. Mean monthly flow and decreed rights for the Hedge, Republican, Corvallis, Supply, and Webfoot diversions on the Bitterroot River during 1985.

	Mean Monthly Flow (ft^3/sec)					
DITCH	MAY	JUNE	JULY	AUGUST	SEPTEMBER	DECREE (ft^3/sec)[1]
Hedge	84	84	126	128	65	140
Republican	159	165	140	125	74	150
Corvallis	128	73	59	29	34	125
Supply[2]	123	166	174	78	51	175
Webfoot[3]	172	170	126	118	57	116

1 Case no. 1287 (State Engineer's Office 1958)

2 Decreed rights for Republican and Wood-Parkhurst (Common headgate)

3 Decreed rights for Webfoot, Union, Etna (Common headgate)

Withdrawals by the five diversions during June, July, August and September, respectively, totaled 18.6, 17.7, 13.5 and 8.0 m^3/sec (658, 625, 478 and 281 ft^3/sec). Withdrawals during July and August were greater than the mean monthly flows recorded at the U.S.G.S. station near Darby (Figure 9). Differences between streamflow and withdrawal were even greater when all diversions on the river were used for comparison. There were an additional 15 unmonitored ditches diverting water during the 1985 irrigation season. Withdrawals by these ditches during the peak of irrigation (July) were estimated to average 0.42 m^3/sec (15 ft^3/sec). As a result, combined withdrawals by all diversion systems on the Bitterroot River during peak irrigation were estimated to total 24.1 m^3/sec (850 ft^3/sec). Without substantial returns by groundwater seepage, flows in the Bitterroot River would not be able to sustain the heavy irrigation demands during July and August. Returns from ditch loss and unconsumed water by flood irrigation significantly add to existing streamflow. These additions provide flows to downstream irrigators and tend to lessen the effects of dewatering in the river.

Supplemental Releases

A supplemental 15,000 AF of water from Painted Rocks Reservoir was available for release into the Bitterroot River by the MDFWP during 1985. The release of this water, shown in Figure 3, was based on a schedule described in a water management plan developed in 1984 (Lere 1984). This schedule was designed to maximize the amount of time a flow of 10.62 m^3/sec (375 ft^3/sec) would be met at Bell crossing. Releases in 1985 were begun on July 12 at a rate of 1.42 m^3/sec (50 ft^3/sec) and were increased to 3.17 m^3/sec (112 ft^3/sec) on July 30. This rate of release was maintained through September 22. Additionally, a test spill of 3.68 m^3/sec (130 ft^3/sec) was conducted from July 23-26 to assess downstream losses. The release of supplemental water ended on September 23.

Due to the severe drought conditions during July, ten irrigation companies purchased a total of 4,600 AF of water from Painted Rocks Reservoir to supplement releases into the river (Table 6). Water for irrigation was released at a rate of 2.12 m^3/sec (75 ft^3/sec) for the periods of July 30 through August 7 and August 30 through September 20. The combined volume of supplemental water released from Painted Rocks Reservoir by the MDFWP and irrigation companies totaled 18,046 AF. These releases were made in addition to the 3.54 m^3/sec (125 ft^3/sec) base flow maintained by DNRC.

Supplemental water released during 1985 was insufficient for maintaining a 10.62 m^3/sec (375 ft^3/sec) target flow at Bell crossing (Table 7). During the period from July 1 through September 30, flows were below the target level for 52 days and were less than 2.83 m^3/sec (100 ft^3/sec) for 20 days. In comparison, flows at Bell fell below the target level for only 1 day during

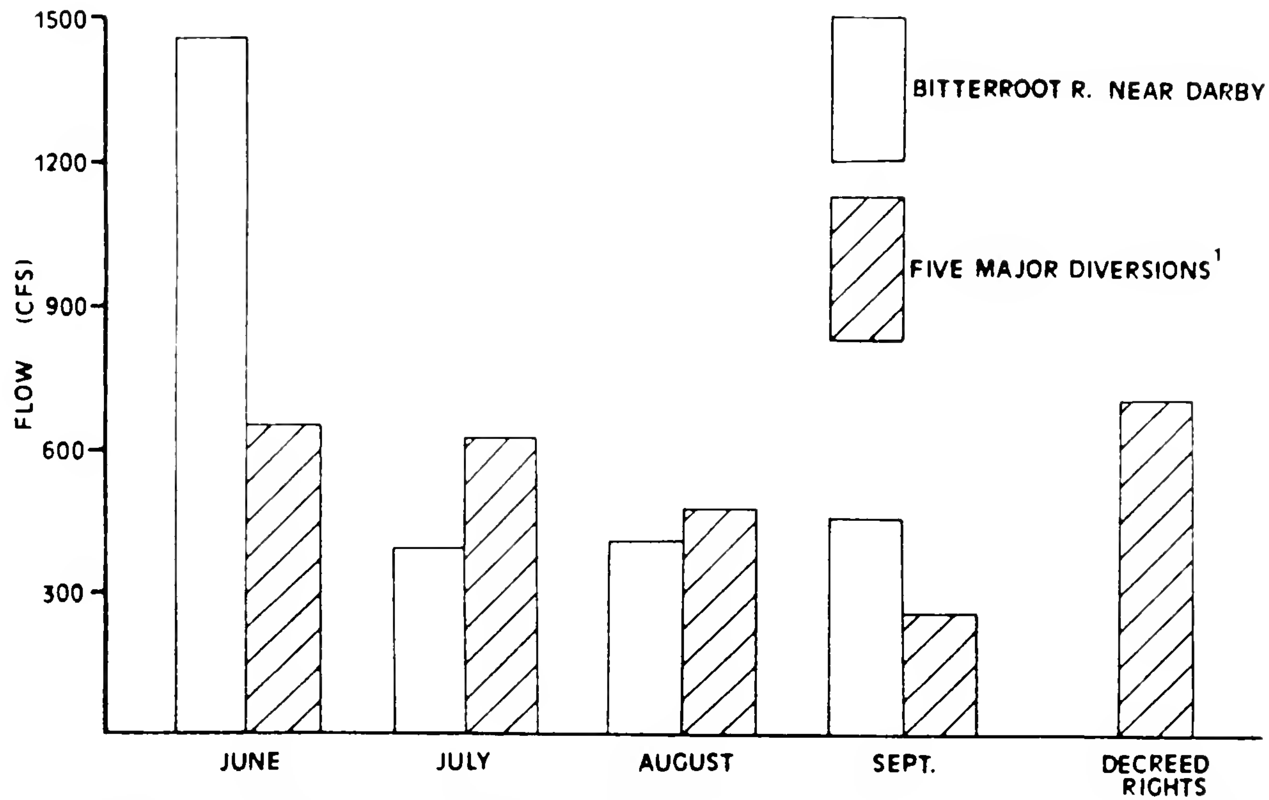

Figure 9. Comparison between mean monthly flow at the U.S.G.S. station near Darby to mean monthly withdrawals by five major diversions on the Bitterroot River during the 1985 irrigation seson.

Table 6. Quantity of water purchased from Painted Rocks Reservoir by irrigation companies during the 1985 irrigation season.

Ditch System	Quantity Purchased (AF)
Whitesell[1]	300
Daly	2500
Overturf	100
Tiedt-Nicholson	100
Ward	300
Woodside	300
Supply	500
Wood-Parkhurst	100
Union	300
Strange	100
Total	4,600

1 From East Fork of Bitterroot River

Table 7. Number of days discharge at Bell crossing was less than or equal to 375, 300, 200 and 100 ft^3/sec for the period from July 1 through September 30 during 1983, 1984 and 1985 (Percentage in parentheses).

Number of days flow (ft^3/sec) was:	1983	1984	1985
≤375	1(1)	11(12)	52(57)
≤300	0(0)	0 (0)	41(45)
≤200	0(0)	0 (0)	21(23)
≤100	0(0)	0 (0)	20(22)

1983 and for only 11 days during 1984. Flows at Bell crossing during 1983 and 1984 were never less than 8.5 m^3/sec (300 ft^3/sec).

Releases made by MDFWP during July, 1985 were not reaching Bell crossing due to extensive diking on the river and to the resultant appropriation by irrigation systems. In an attempt to protect supplemental releases from being appropriated, the MDFWP requested water users on the river to petition the district court for the appointment of a water commissioner. An agreement between MDFWP and the owners of decreed water rights on the river to file this petition was reached on July 29. As a result, a commissioner was appointed August 2 with the understanding that MDFWP would pay his entire cost and that only 75% of the MDFWP supplement released from Painted Rocks Reservoir would reach Bell crossing. This agreement remained relatively untested, however, because flows in the river substantially increased during early August as a result of above normal precipitation.

Test Release from Painted Rocks Reservoir

A test release from Painted Rocks Reservoir was conducted during July, 1985 to quantify downstream losses of supplemental water due to natural phenomenon and to appropriation by irrigation systems. Approximately 721 AF of supplemental water were released from the reservoir at a rate of 3.68 m^3/sec (130 ft^3/sec) during the test (Appendix A6). The release was conducted for a period of 68 hours beginning on July 23 and was monitored at five downstream gauging stations.

Flows released during the test were progressively diminished as the additional water moved downstream. Approximately 14% of the original release was lost before reaching the Darby station and about 52% of the original release was lost before passing the Hamilton station (Figure 10). Nearly all of the remaining supplemental water was diverted or lost from the river before reaching Bell crossing. Gravel dikes constructed upstream from Bell crossing were effectively blocking all flow in the river. Since a greater percentage of the original release reached the Poker Joe station than the Bell station, flows apparently were being diverted around the reach of river at Bell crossing and were being returned to the river via irrigation drains upstream from Poker Joe.

Supplemental flows were diminished to a greater extent during the 1985 test release than during tests conducted in 1984. The greater losses incurred during the 1985 test were a direct result of the severe drought conditions. Because of the drought, diking in the river and the resultant appropriation of water into irrigation systems was much more extensive during 1985 than 1984. Approximately 57% (414 AF) of the original 1985 release was appropriated from the river by the five monitored diversions (Figure 11). Flows in the Hedge, Republican, Corvallis, Supply

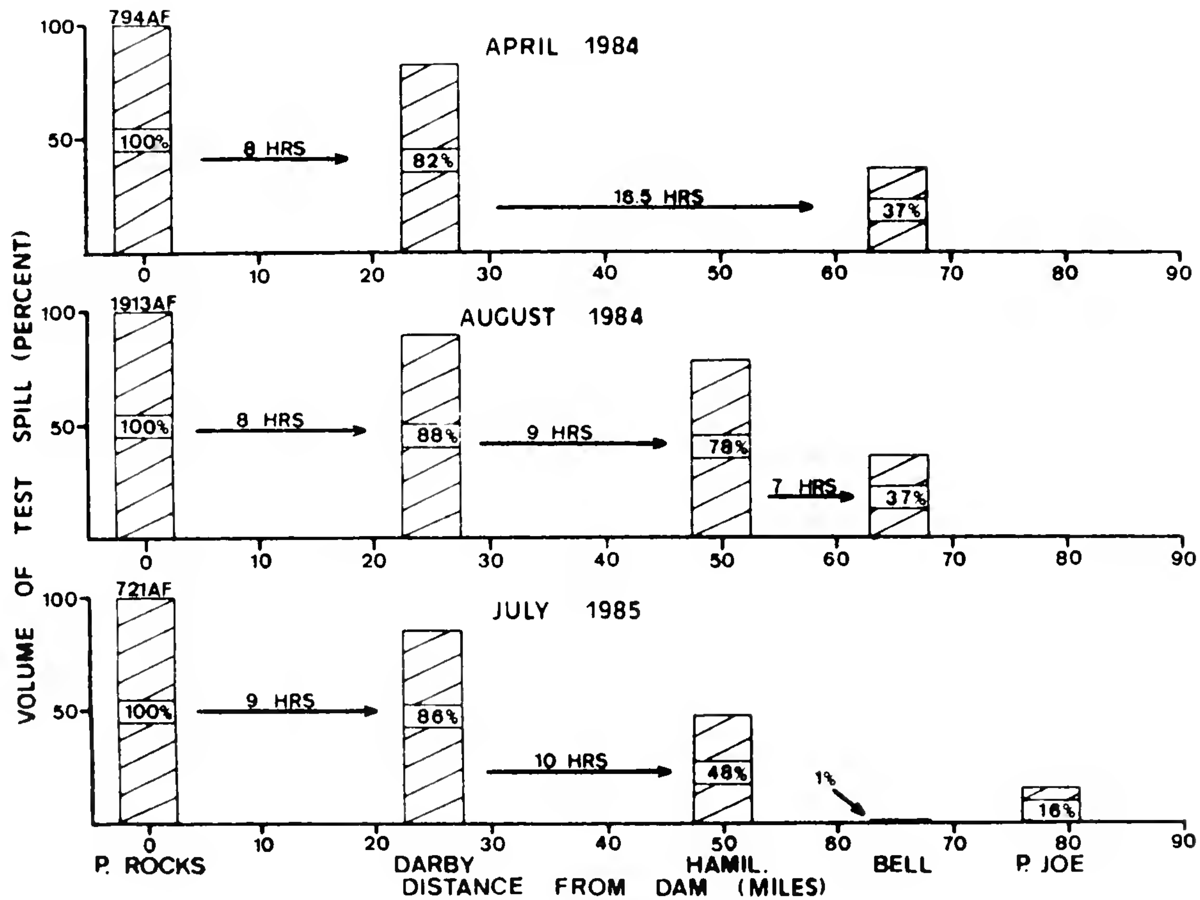

Figure 10. Test spills conducted from Painted Rocks Reservoir during 1984 and 1985 showing travel times and changes in volume as water releases passed downstream stations.

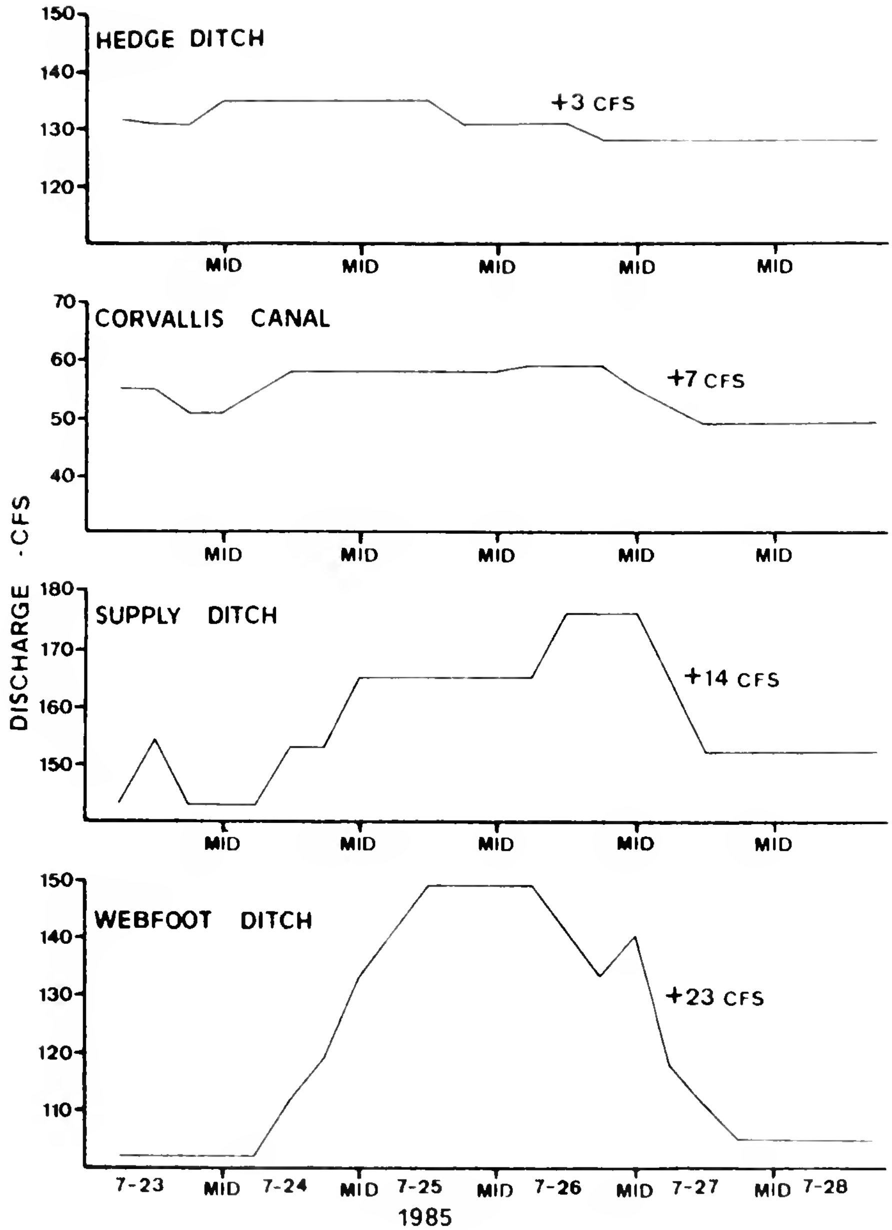

Figure 11. Hydrographs derived for the Hedge, Corvallis, Supply and Webfoot diversions following the test release of 721 AF from Painted Rocks Reservoir during 1985.

and Webfoot diversions gained an average of 0.08, 0.79, 0.20, 0.40 and 0.65 m^3/sec (3, 28, 7, 14 and 23 ft^3/sec), respectively, as the test spill passed through the system. The gain for each ditch system appeared to be a function of headgate design and the size of the dam at the point of diversion.

Drafting of Reservoir

The elevation of the water level in Painted Rocks Reservoir was monitored periodically during the 1985 irrigation season to evaluate the effects of accelerated drafting due to the release of purchased water. Elevations and associated storage volumes measured at the reservoir are presented in Table 8. All usable storage in Painted Rocks Reservoir was drained during 1985 to meet the base flow policy of DNRC and to provide for the release of purchased water. The level of the reservoir, following spring runoff, remained at or above full pool through early July. From mid July through mid November the reservoir level was steadily drawn down. By December 1, the level of the reservoir was down to the elevation level of the outlet.

End of the month contents for June through October were less than the 90% exceedence values shown in Table 9 (given by Brown 1982). In addition to the release of approximately 18,000 AF of purchased water, the early summer drought also contributed the accelerated drafting of the reservoir. Total inflow to the reservoir was estimated to average 2.80 m^3/sec (99 ft^3/sec) during July, 1.90 m^3/sec (67 ft^3/sec) during August and 2.27 m^3/sec (80 ft^3/sec) during September. Inflows for July and August, respectively, were less than the median values of 6.94 m^3/sec (245 ft^3/sec) and 3.20 m^3/sec (113 ft^3/sec) given by Brown (1982).

Water Temperatures

West Fork of Bitterroot River

Water temperatures in the West Fork of the Bitterroot River near the base of Painted Rocks Reservoir were monitored from March 11 through December 21, 1985. Recordings from a maximum/minimum thermometer and individual observations are presented in Figure 12. Water temperatures ranged from 0.3 to 17.8 C (32.5 to 64 F) during 1985. Temperatures warmed progressively through June, cooled somewhat during July, and then warmed again through mid September. The maximum recorded temperature was reached during the second half of September. The cooling trend that occurred during July was probably due to the ending of reservoir spill following runoff. Water spilled (uncontrolled) from the crest is probably warmer than water released from the outlet at the base of the dam. Water temperatures did not appear to be significantly effected by the release of supplemental water. Spot observations on July 30 indicated temperatures cooled about 1.1 C (2.0 F) upon the release of an additional 3.09 m^3/sec (109 ft^3/sec) from the reservoir.

Table 8. Water elevations and associated storage measured in Painted Rocks Reservoir during 1985.

Date	Elevation[1] (ft)	Storage[2] (acre-feet)
6-14-85	4,725.92	31,998
6-27-85	4,725.57	31,707
7-11-85	4,725.01	31,409
7-29-85	4,717.61	26,922
8-12-85	4,707.41	21,403
8-26-85	4,697.18	16,652
9-16-85	4,672.68	8,752
10- 3-85	4,659.42	5,439
10-23-85	4,651.41	3,848
12- 1-85	4,625.50[3]	656

[1] Elevation of spillway is 4,725.3 ft.

[2] Storage values for 6-14 through 8-26 were determined by a DNRC rating table and for 9-16 through 12-1 values were obtained from a rating table given by Brown (1982).

[3] Elevation of outlet

Table 9. Median and 90% exceedence values for month-end contents at Painted Rocks Reservoir.[1]

Month	Month-end Contents (AF) Median	90% Exceedence	1985[2]
June	32,070	31,765	31,707
July	31,960	29,840	26,922
August	30,625	21,711	16,652
September	27,215	12,850	5,439
October	21,275	6,000	3,848

[1] From Brown (1982)

[2] Values obtained within 7 days of the end of the month.

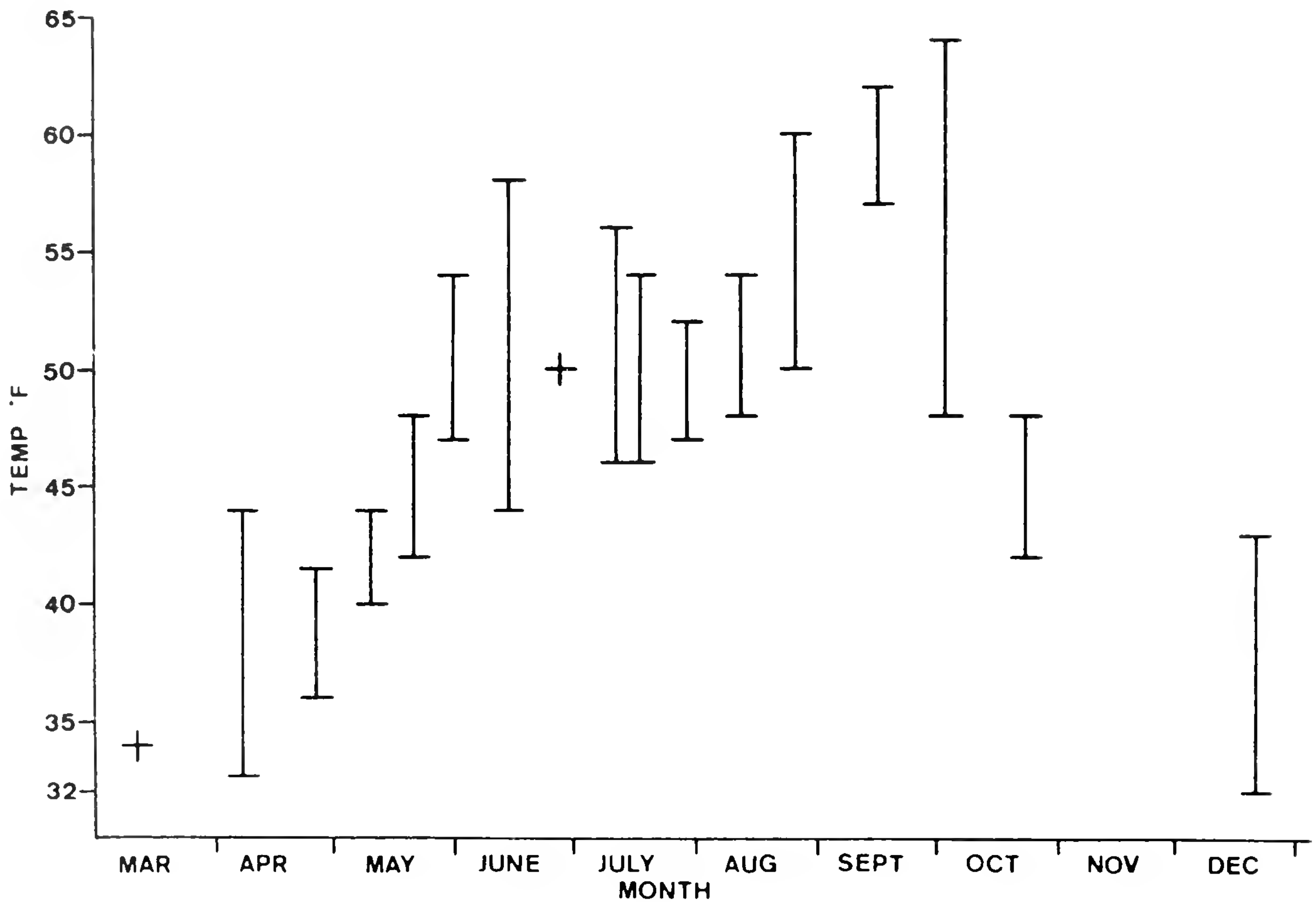

Figure 12. Water temperatures monitored in the West Fork of the Bitterroot River near Painted Rocks Reservoir during 1985. Bars represent maximum/minimum thermometer readings. Plus signs represent individual thermometer readings.

Main Stem of the Bitterroot River

Water temperatures in the Bitterroot River were monitored from early March through late November at stations established near Darby, Hamilton, Bell crossing and Maclay bridge (Figure 1). Temperatures in the river progressively warmed from early March through mid July (Figures 13 and 14). In addition, water temperatures progessively warmed in a downstream direction to Bell crossing. However, daily maximum temperatures remained similar between Bell crossing and Maclay bridge through the monitoring period. Cooler tributary inflow and groundwater seepage probably prevented further warming of the river downstream from Bell crossing. Maximum water temperatures recorded at the Darby, Hamilton, Bell and Maclay stations were 20.6, 23.4, 22.8 and 22.2 C (69, 74, 73 and 72 F), respectively. Maximum temperatures for each station were recorded on July 9 or July 10, two or three days prior to the period of severe dewatering.

Daily maximum temperatures recorded during the monitoring period averaged 10.6, 11.9, 12.8 and 12.7 C (51.0, 53.4, 55.1 and 54.8 F) at the Darby, Hamilton, Bell and Maclay stations, respectively. Fluctuations in daily temperature at the respective stations averaged 3.6, 3.6, 3.4 and 1.8C (6.5, 6.4, 6.1 and 3.3 F). Daily records of maximum and minimum water temperature for the four stations are given in Appendix B1.

Monthly means of maximum water temperature (daily) recorded during 1985 are compared to 1984 means in Figure 15. Maximum temperatures from April through July were warmer in 1985 than in 1984. In contrast, maximum temperatures from August through November were generally cooler during 1985. Contrasts in temperature were likely related to the differing weather patterns betwen years.

Water temperatures that are greater than 17-20 C (63-68 F) have been shown to exceed the physiological optimum for growth in salmonids (Brett et al. 1969, Brockson and Bugge 1974). Temperatures during 1985 exceeded 19.4 C (67 F) on 5, 42, 36 and 36 days, respectively, at the Darby, Hamilton, Bell and Maclay stations. These data indicate water temperatures in the Bitterroot River upstream from Darby were probably optimal for trout survival. Although probably adequate, water temperatures downstream from Hamilton were somewhat less than optimal for trout viability during 1985. Main stem water temperatures did not appear to be significantly effected by supplemental releases from the reservoir.

Somewhat unexpectedly, the severe dewatering that occurred during 1985 did not generate critically warm water temperatures in the river. The potential for high temperatures associated with dewatering appeared to be moderated by cooler groundwater seepage into the Bitterroot River.

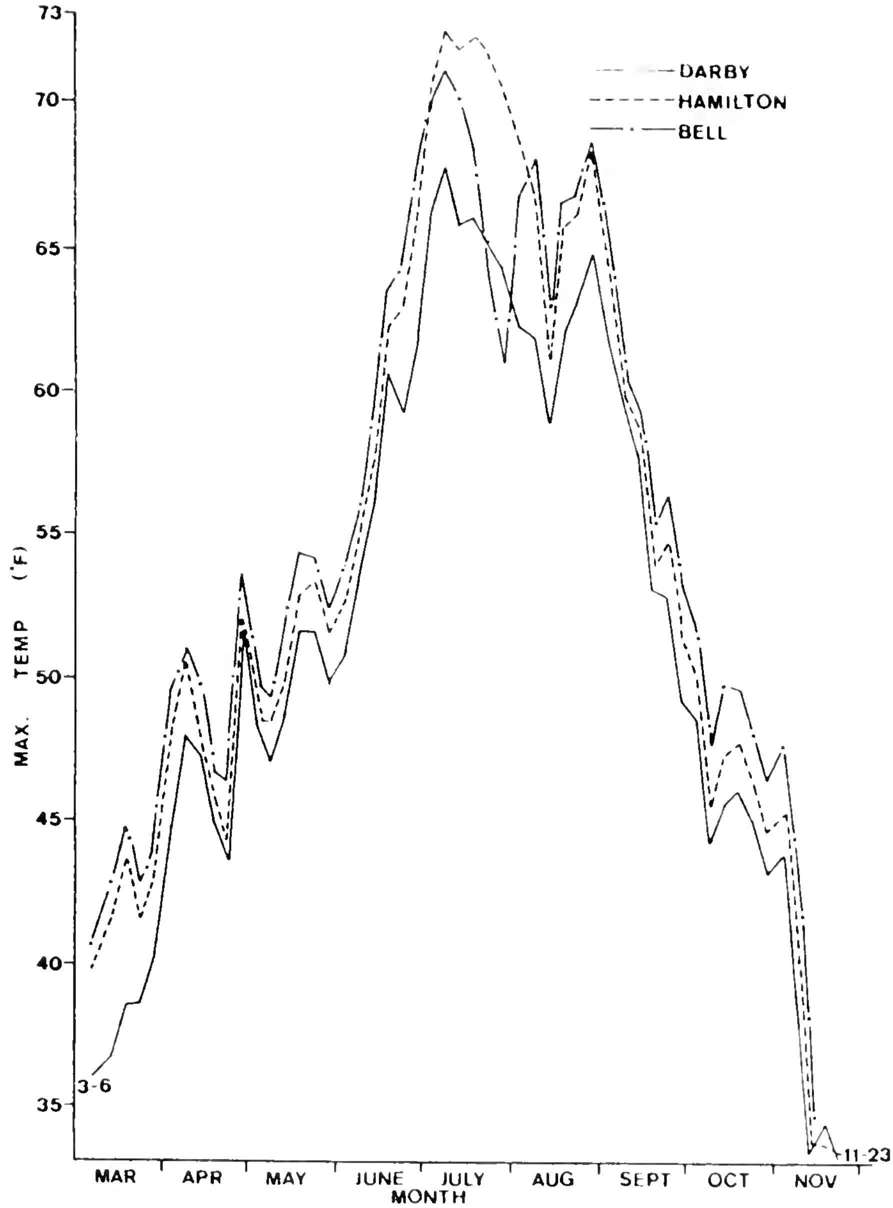

Figure 13. Five day averages of maximum water temperatures recorded at the Darby, Hamilton and Bell stations on the Bitterroot River during 1985.

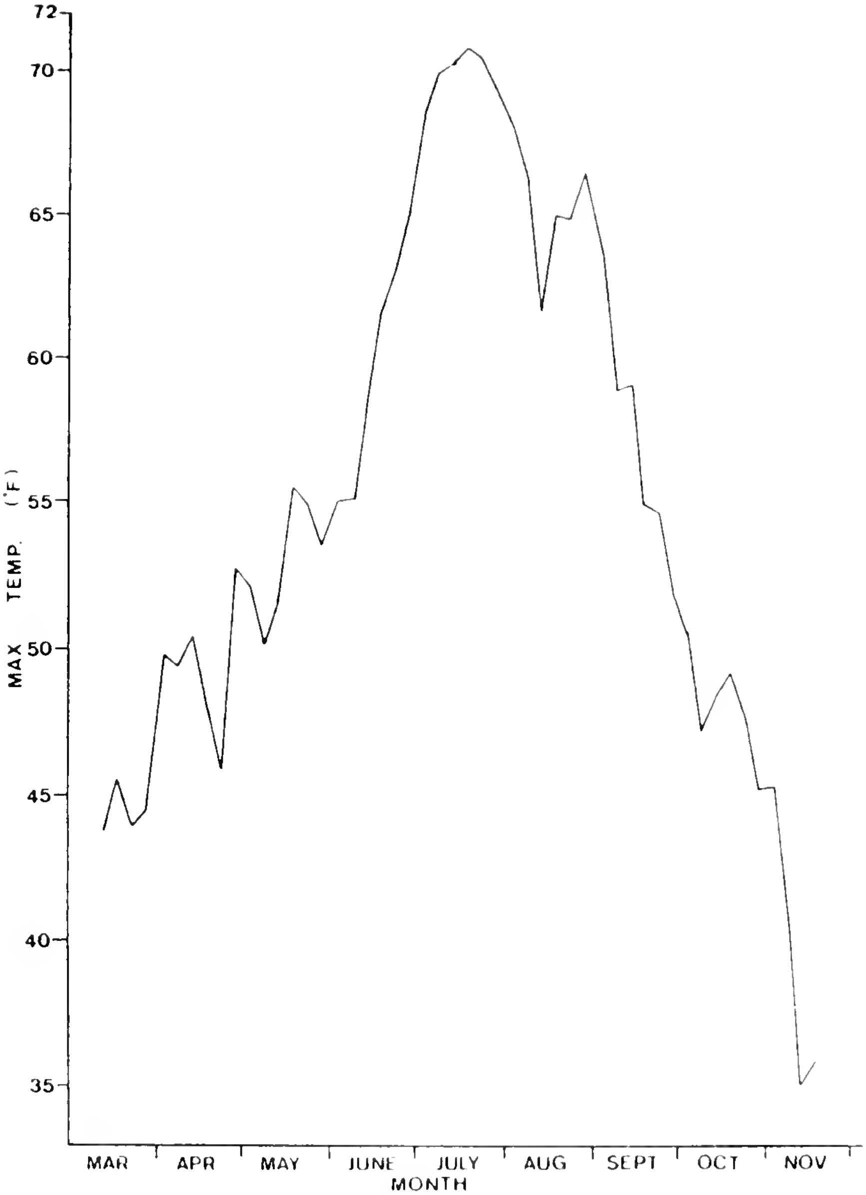

Figure 14. Five-day averages of maximum water temperatures recorded at the Maclay station on the Bitterroot River during 1985.

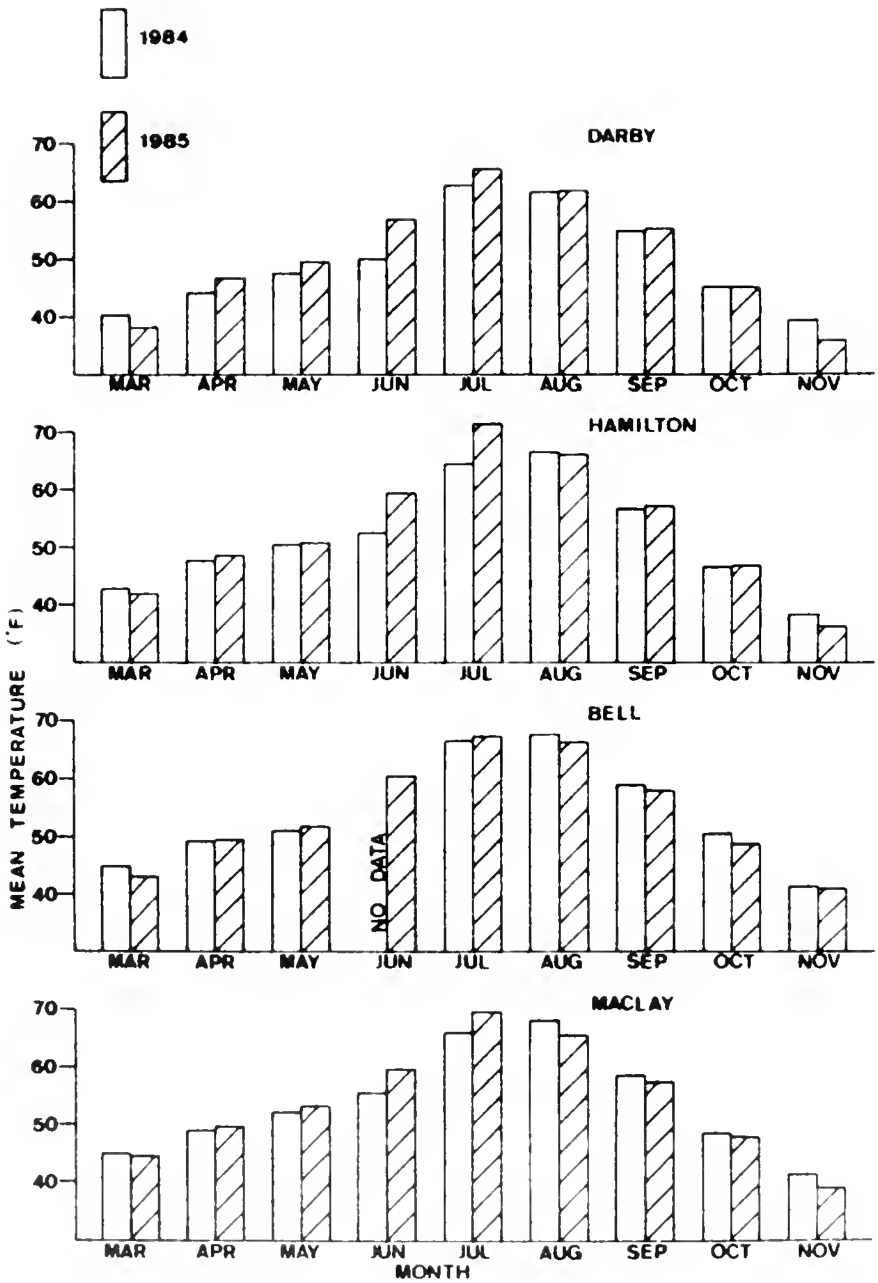

Figure 15. A comparison of monthly means of daily maximum water temperatures recorded at four stations on the Bitterroot River during 1984 and 1985.

Fish Populations

Species Composition

Eighteen species representing 7 families of fish are present in the Bitterroot River (Table 10). Of these, 14 species have been captured since the inception of the study. Predominant gamefish, in order of abundance, were mountain whitefish, rainbow trout and brown trout. Predominant non-game species included largescale and longnose suckers, longnose dace, redside shiner, northern squawfish and slimy sculpin.

Spring Population Estimates

The numbers and sizes of each species of trout captured in the Darby and Tucker sections during the Spring, 1985 are presented in Appendix C1. Rainbow trout comprised a majority of the total numbers collected in the Darby section (control) and brown trout comprised a majority of the total numbers collected in the Tucker section (dewatered). Both rainbow trout and brown trout collected in the Darby section averaged less in total length and weight than those collected in the Tucker section. Length frequency distributions for rainbow trout and brown trout collected during the spring are presented in Appendix C2 and C3, respectively.

Estimates of the numbers and biomass of age II+ and older rainbow trout and brown trout obtained during the Spring, 1985 are presented in Appendix C4. Densities for both rainbow trout and brown trout were significantly less in the Darby section than in the Tucker section. These data, however, are not comparable to previous fall estimates due to the inability to obtain estimates for yearling fish and due to the likelihood that adult rainbow trout were migrating into the tributaries to spawn during the spring.

Estimated numbers of rainbow trout and brown trout obtained during the Spring, 1985 are compared to 1984 spring estimates in Figure 16. With the exception of rainbow trout in the Darby section, estimated numbers of trout did not significantly vary between 1984 and 1985. Rainbow trout numbers in the Darby section, however, significantly declined between years. The decline in 1985 may have been due, in part, to an overlapping between the time estimates were completed and the start of the rainbow spawning season. Since population estimates were completed approximately two weeks later in 1985 than in 1984, it is likely that more spawners had moved into the tributaries prior to the finish of the 1985 estimate.

Fall Population Estimates

The numbers and sizes of each species of trout captured in the Darby (control), Tucker (dewatered) and Poker Joe (rewatered) sections during the Fall, 1985 are presented in Appendix C5.

Table 10. Fish species present in the Bitterroot River (Relative abundance in parentheses).[1]

SALMONIDAE	
Salmo gairdneri	*Rainbow trout (A)
Salmo trutta	*Brown trout (A)
Salmo clarkii	*Cutthroat trout (C)[2]
Salvelinus fontinalis	*Brook trout (C)[2]
Salvelinus confluentus	*Bull trout (R)
Prosopium williamsoni	*Mountain whitefish(A)
ESOCIDAE	
Esox lucius	Northern pike (R)
CYPRINIDAE	
Rhinichthys cataractae	*Longnose dace (A)
Mylocheilus caurinus	Peamouth (R)
Richardsonius balteatus	*Redside shiner (A)
Ptychocheilus oregonensis	*Northern squawfish (A)
CATOSTOMIDAE	
Catostomus catostomus	*Longnose sucker (A)
Catostomus macrocheilus	*Largescale sucker (A)
CENTRARCHIDAE	
Micropterus salmoides	*Largemouth bass (R)
Lepomis gibbosus	*Pumpkinseed (R)
PERCIDAE	
Perca flavescens	Yellow perch (R)
COTTIDAE	
Cottus cognatus	*Slimy sculpin (A)
Cottus confusus	Shorthead sculpin (U)

[1] Relative abundance - A=abundant, C=common, R=rare, U=status unkown.
[2] Abundant in tributaries.

*Species captured since inception of study.

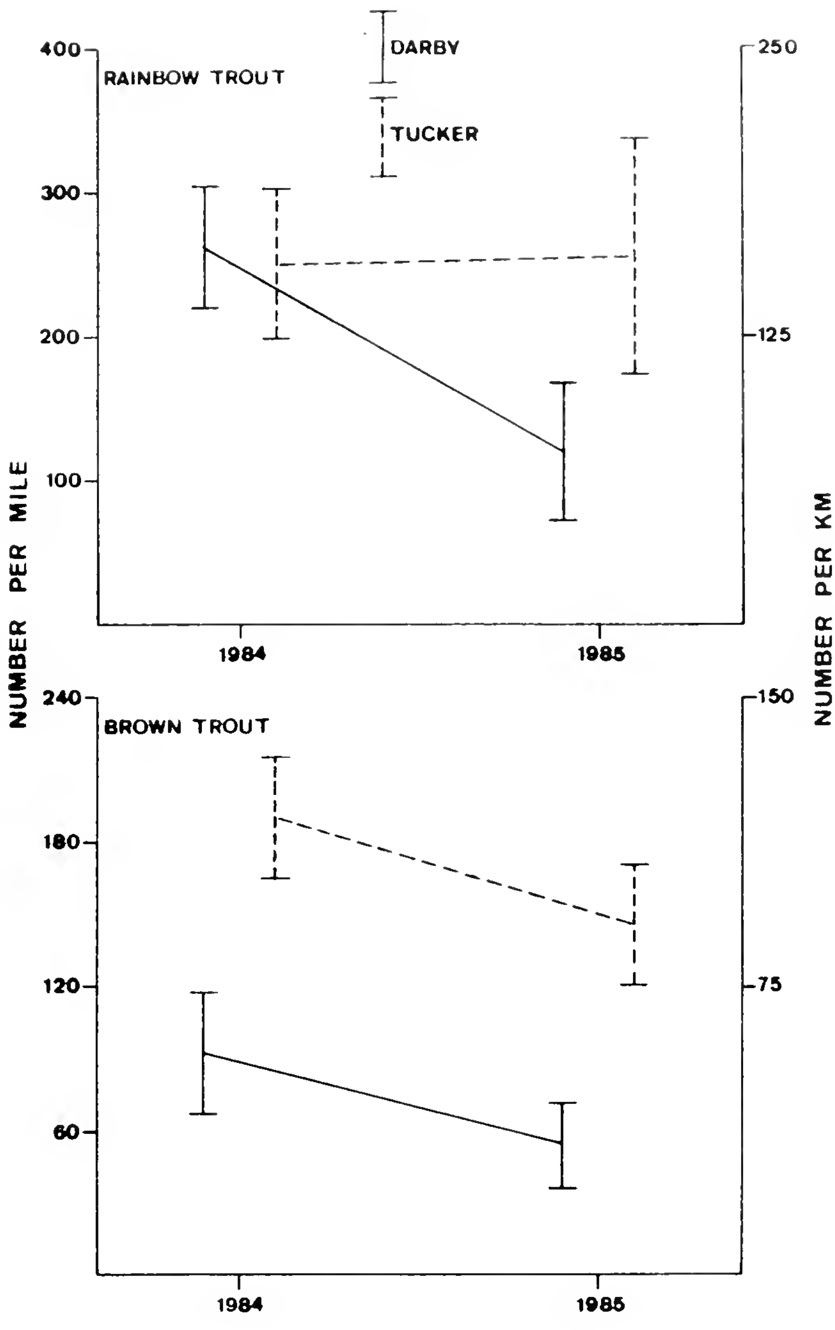

Figure 16. Numbers of rainbow trout and brown trout estimated in study sections of the Bitterroot River during the Spring, 1985 with comparable estimates obtained during the Spring, 1984. Bars represent 80% confidence intervals.

Rainbow trout was the predominant species captured in the Darby and Poker Joe sections, comprising 56 and 85%, respectively, of the total numbers of trout collected. In contrast, brown trout was the predominant species captured in the Tucker section, comprising 62% of the total numbers of trout collected. The mean total length and weight of captured rainbow trout was least in the Darby section, intermediate in the Tucker section and greatest in the Poker Joe section. For brown trout, mean total length and weight was least in the Darby section and greatest in the Tucker section. Length frequency distributions for rainbow trout and brown trout collected during the fall are presented in Appendix C6 and C7, respectively.

Estimates of the numbers of rainbow trout and brown trout obtained in the three sections during the Fall, 1985 are shown in Figure 17. Estimated numbers of rainbow trout per kilometer were significantly greater in the Darby section than in the Tucker or Poker Joe sections. Estimated numbers of brown trout, in contrast, were similar between the Darby and Tucker sections. In the Poker Joe section, too few brown trout were captured to obtain an estimate.

The low population levels of trout estimated in the Poker Joe section were unexpected since this reach of river did not appear to have dewatering problems, poor habitat characteristics (unmeasured) or unfavorable water quality (selected parameters presented in Lere 1984). Although not assessed, densities of rainbow trout and brown trout in the Poker Joe section may be limited by inadequate recruitment of juveniles into the populations. Few tributaries enter into this reach of river to provide spawning and rearing habitat for trout.

Samples of scales collected during the Fall, 1985 are currently being mounted on acetate slides. Population estimates will be computed for individual age groups (age I+ and older fish) when scale analyses are completed and will be presented in the final report.

Changes in Trout Populations

The numbers of rainbow trout in the Darby section have increased approximately 246% since population estimates were first obtained in 1982 (Figure 18). This increase may have been due to a change to restrictive fishing regulations begun in 1982 and/or to the release of supplemental water (15,000 AF) from Painted Rocks Reservoir begun in 1983. Although the data were inconclusive, the increase in rainbow trout numbers in the Darby section appeared to be attributable more to supplemental water releases than to regulation changes.

Possession limits in the Darby section were changed from a limit of 10 fish or 4.5 km (10 lbs) plus 1 fish to 5 fish under 356 mm (14 in) or 4 fish under 356 mm (14 in) and 1 fish over

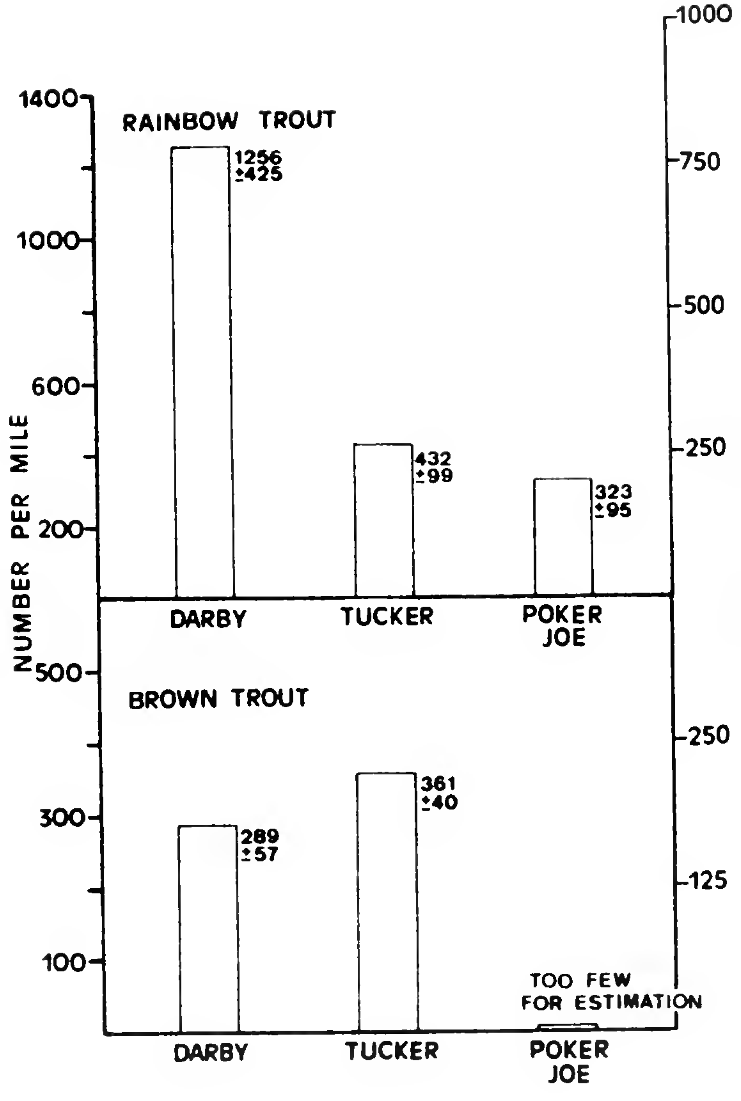

Figure 17. Estimated numbers of rainbow trout and brown trout obtained in the study sections of the Bitterroot River during the Fall, 1985. Plus or minus 80% confidence intervals.

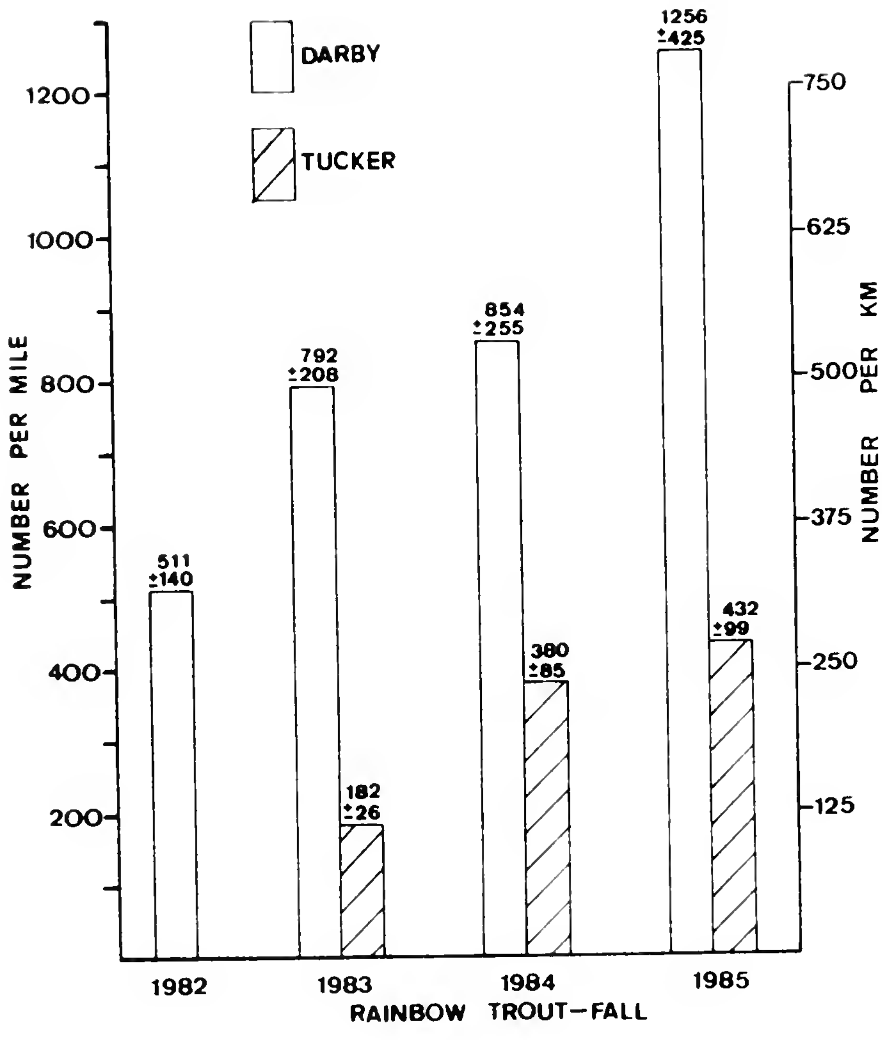

Figure 18. Numbers of rainbow trout estimated in the study sections of the Bitterroot River during the Fall, 1985 with comaprable estimates obtained in 1982, 1983 and 1984. Plus or minus 80% confidence intervals

457 mm (18in). Regulations also were restricted to the use of artificial lures. Regulations were restricted in the Darby section in an attempt to increase the number of fish greater than 356 mm (14 in) in length. However, estimated numbers of these larger fish have not substantially changed since 1982.

Supplemental releases from Painted Rocks Reservoir have increased mean monthly flow in the Darby section by about 2.12 m^3/sec (75 ft^3/sec) during August and September (Figure 19). This additional water in the Darby section appeared to improve recruitment of yearlings into the population. Although population increases in the Darby section appeared to be primarily attributable to supplemental water releases, changes in rainbow trout numbers could not be directly correlated with summer flows.

In the Tucker section, numbers of rainbow trout have increased approximatley 237% since population estimates were first obtained in 1983 (Figure 18). Possession limits in this section were changed in 1982 from a limit of 10 fish or 4.5 km (10 lb) plus 1 fish to 5 fish with only 1 of which could exceed 356 mm (14 in) in length. Again, population increases may have been due to regulation changes and/or supplemental water releases. However, it is unlikely that the rainbow population in the Tucker section has been enhanced by supplemental releases from the reservoir since a majority of the water released has been lost via natural phenomon or appropriation before ever reaching this section of the river.

The severe dewatering of the river during July, 1985 did not result in a decline in the numbers of adult rainbow trout in the Tucker section. Since critical dewatering in the river occurred for only a relatively brief period of time, adult rainbow trout may have been able to endure the adverse effects of low flow. Additionally, any adverse effects of dewatering on an already depressed rainbow trout population may have been undetectable. Although not assessed, numbers of young of the year rainbow trout may have been significantly reduced by dewatering since rearing areas are among the first types of habitat to be effected by flow reductions. (Sando 1981).

The numbers of brown trout in the Darby section have not significantly changed since population estimates were first obtained in 1982 (Figure 20). Apparently, the change to more restrictive fishing regulations and the release of supplemental water from the reservoir have not significantly enhanced adult brown trout populations in the Darby section. In contrast, brown trout numbers in the Tucker section have increased approximately 162% since population estimates were first obtained in 1983. The severe dewatering during 1985 did not result in a decline in the numbers of adult brown trout in the Tucker section. As with rainbow trout, however, young of the year brown trout may have been substantially effected by depletions in flow. Further assessments are needed to determine the effects of dewatering on the rearing habitat of young of the year trout in the Bitterroot River.

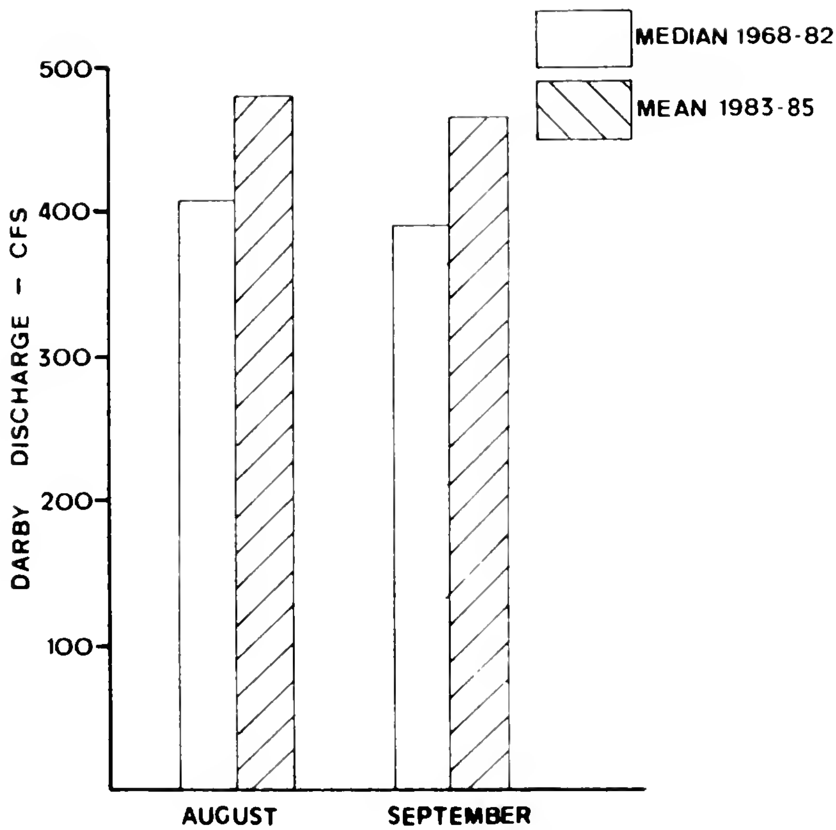

Figure 19. Average August and September discharge of the Bitterroot River at the U.S.G.S. station near Darby for the 3 years supplemental water has been released from Painted Rocks Reservoir (1983-85) with comparable median values obtained from 15 years of historic record (1968-82).

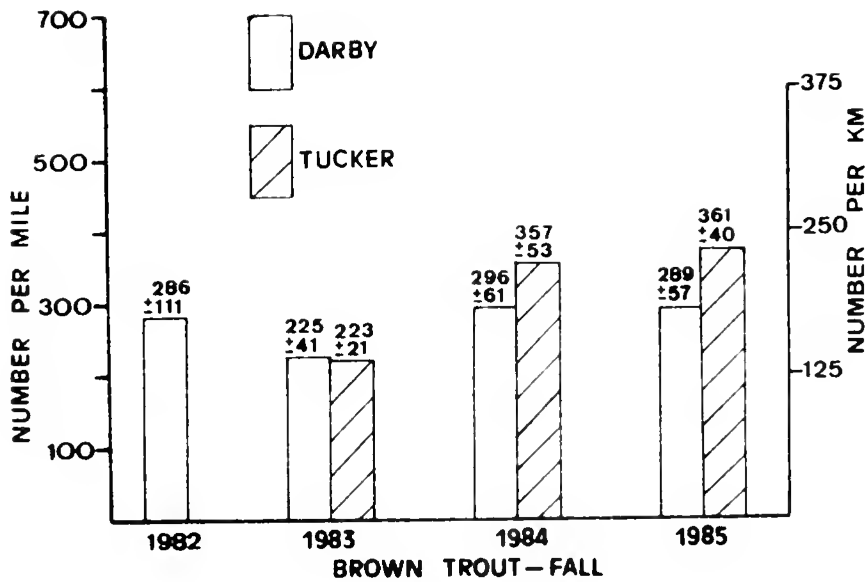

Figure 20. Numbers of brown trout estimated in the study sections of the Bitterroot River during the Fall, 1985 with comparable estimates obtained in 1982, 1983 and 1984. Plus or minus 80% confidence intervals.

Age Structures of Trout Populations

Age structures of rainbow trout populations in the Darby and Tucker sections are compared in Figure 21. In the Darby section, age I+ fish comprised the greatest proportion of numbers among age groups for estimates obtained during 1982, 1983 and 1984. Numbers of rainbow trout in all age groups, especially age I+ fish, increased between 1982 and 1984. The release of additional water from the reservoir apparently has enhanced habitat for young of the year fish and, as a result, has increased the number of fish surviving to become yearlings. The increase in the numbers of age III+ and older fish may have been due to the change to more restrictive fishing regulations.

For the population estimate obtained in the Tucker section during 1983, age III+ and older rainbow trout predominated numbers among age groups. In contrast, age I+ and II+ fish predominated numbers among age groups during 1984. The increase in the numbers of age I+ and II+ rainbow trout between 1983 and 1984 may have been due to improved survival of juveniles and/or immigration of juvenile and yearling fish into the section.

Age structures of brown trout populations in the Darby and Tucker sections are compared in Figure 22. Age I+ brown trout predominated numbers among age groups in the Darby section. Again, increased numbers of yearling fish between 1983 and 1984 indicated recruitment may have been enhanced by water releases. In the Tucker section, age IV+ and older fish comprised the greatest proportion of numbers among age groups during 1983. In 1984, however, brown trout numbers were almost equally distributed among age groups due to increases in the numbers of age I+, II+ and III+ fish. The increase in brown trout numbers between years appeared to be attributable to immigration of fish into the section.

Comparison of Standing Crop Between Sections

Total numbers and biomass of trout are compared between the Darby and Tucker sections in Figure 23. Total numbers of trout were significantly greater in the Darby section than in the Tucker section for all fall estimates. Fewer numbers of fish in the Tucker section indicate that dewatering during the irrigation season is reducing the carrying capacity for trout within this reach of the Bitterroot River.

Total biomass estimates of trout, in contrast with numbers, were not significantly different between sections for all fall estimates. Similar biomass estimates between sections, however, does not necessarily indicate population levels in the Tucker section are not being limited by a dewatering problem. The dewatered reach of the river, if not severely depleted by

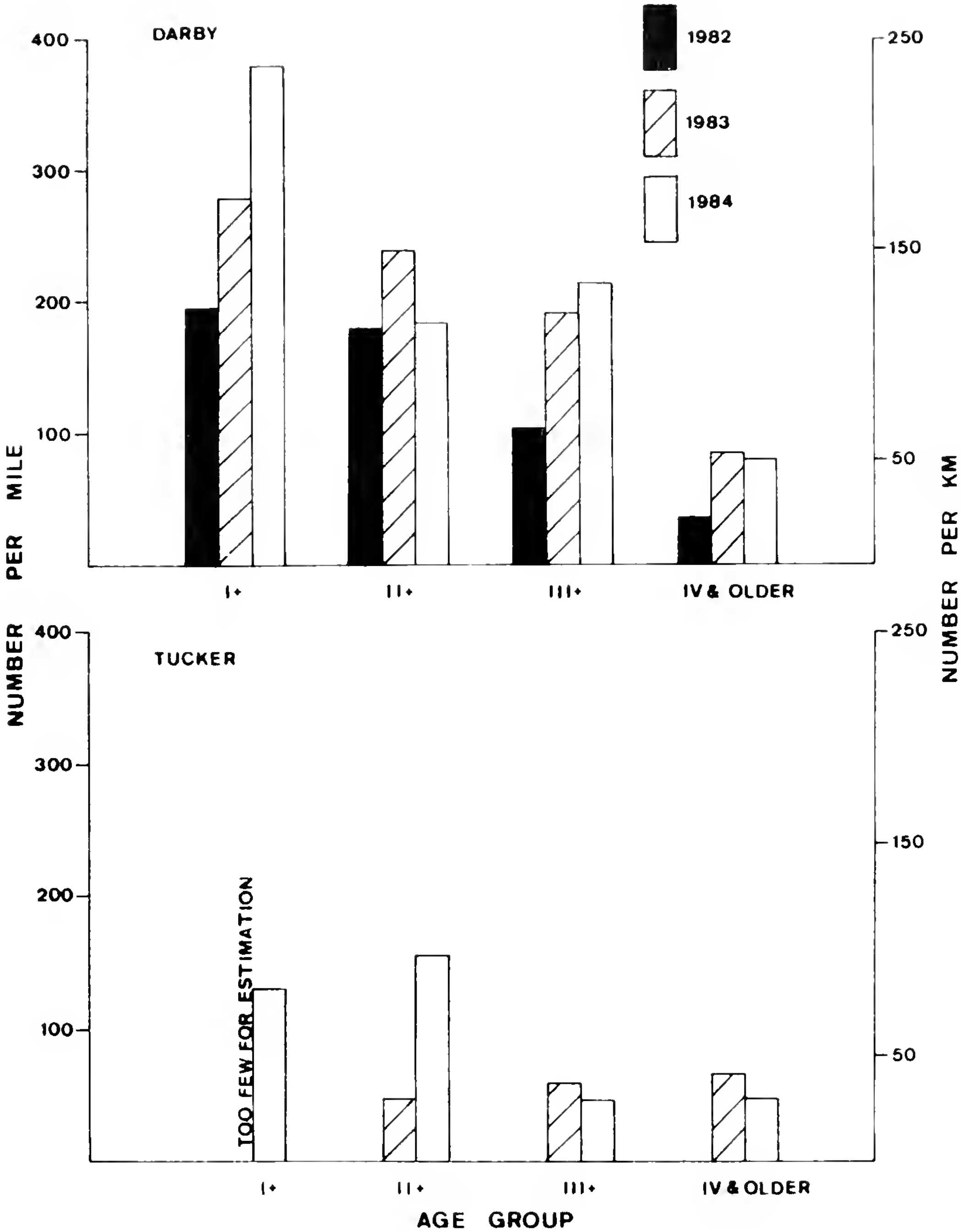

Figure 21. Age structures of rainbow trout populations estimated in the study sections of the Bitterroot River during the fall of 1982, 1983 and 1984.

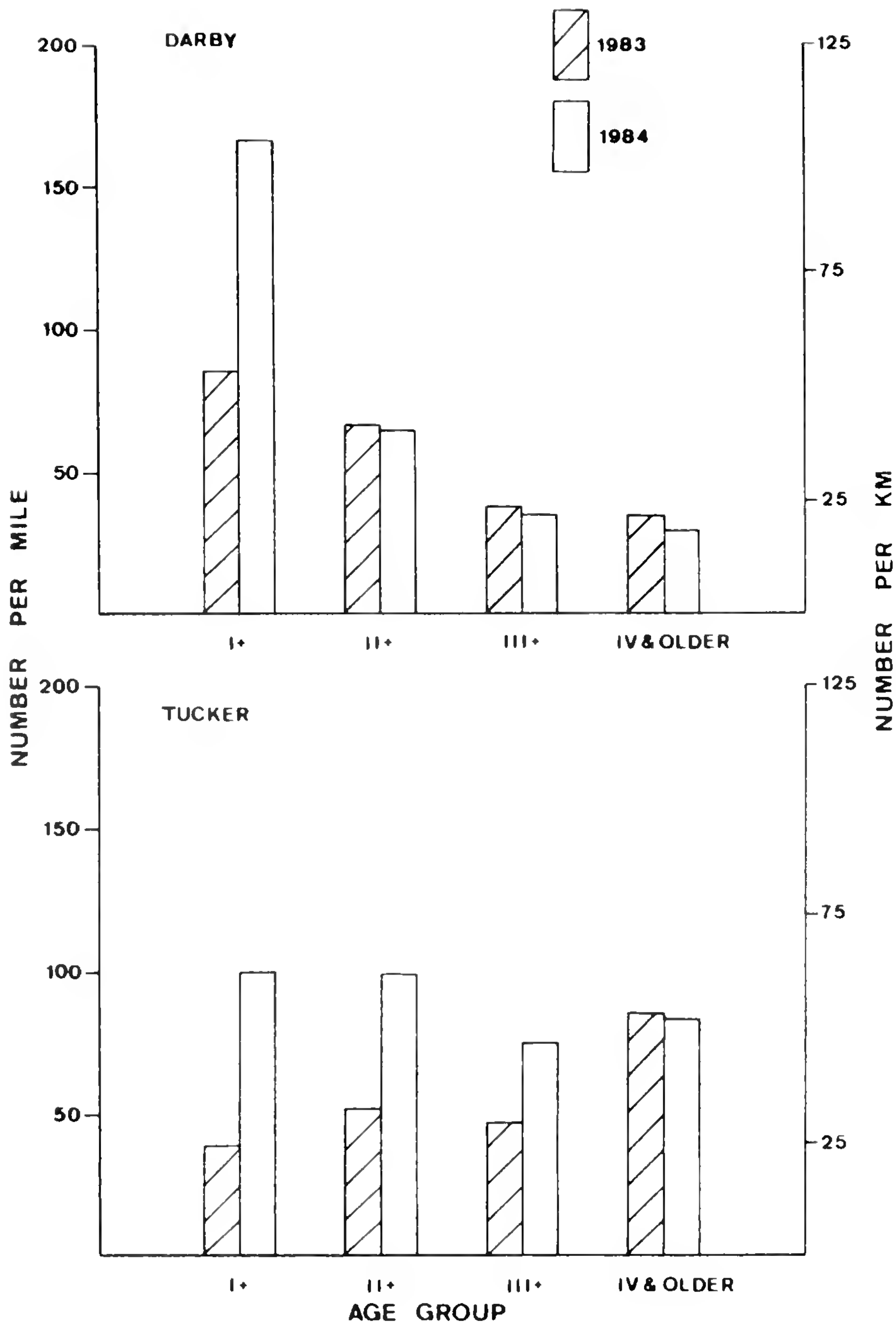

Figure 22. Age structures of brown trout populations estimated in the study sections of the Bitterroot River during the fall of 1983 and 1984.

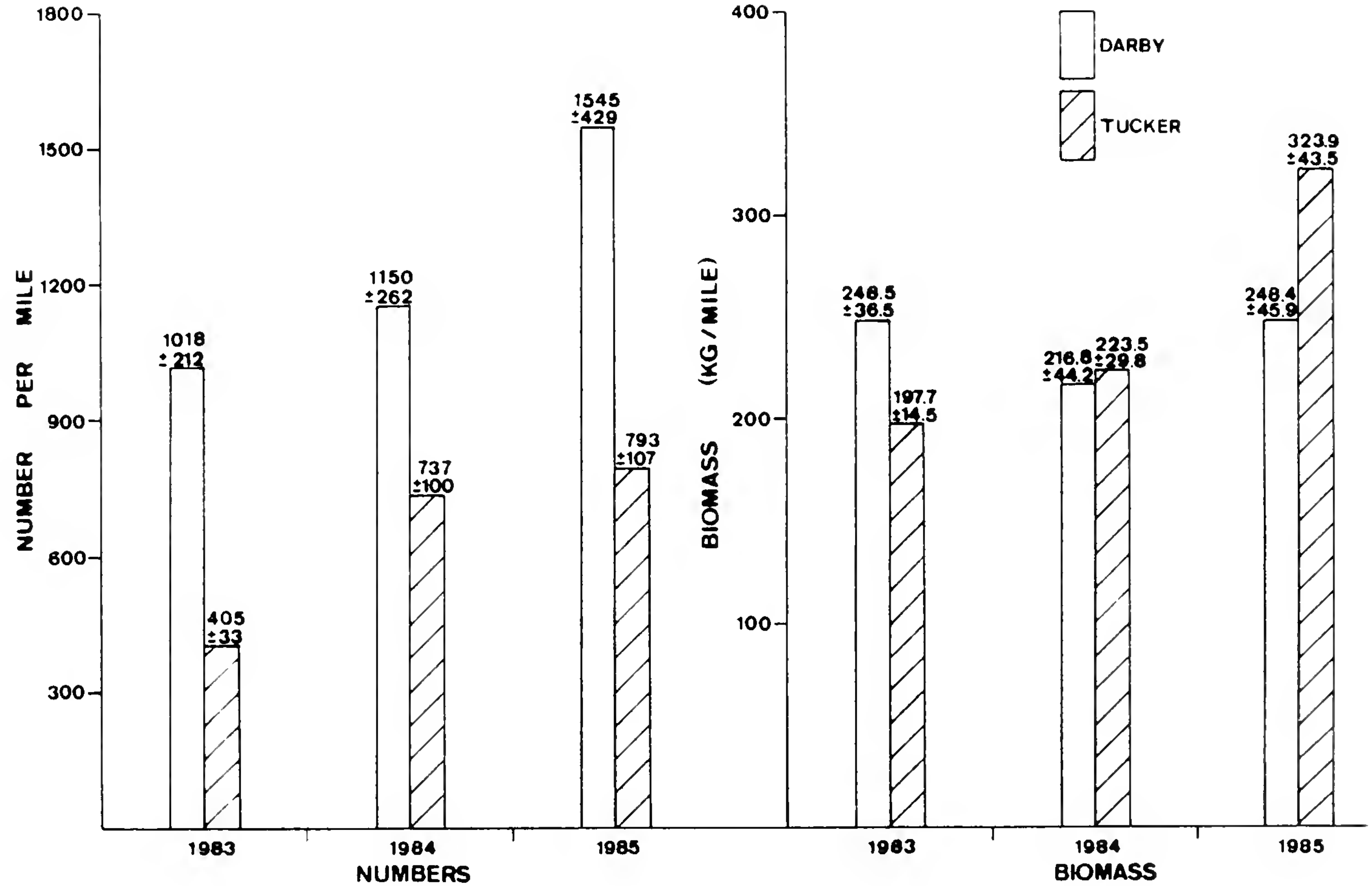

Figure 23. Estimates of the total number and biomass of trout in the Darby and Tucker sections of the Bitterroot River during the Fall, 1985 with comparable estimates obtained during 1983 and 1984. Plus or minus 80% confidence intervals.

irrigation withdrawals, would have greater summer flows than the Darby section. Without the dewatering problem, the standing crop of trout should be greater in the Tucker section than the Darby section since more water would provide more space for fish.

Condition Factors for Trout

The mean condition factors (a measure of fitness) for rainbow trout and brown trout captured in the Darby, Tucker and Poker Joe sections during 1982, 1983, 1984 and 1985 are presented in Table 11. These data indicate the condition of rainbow trout and brown trout in all three study sections is relatively good. Mean condition factors for both species did not significantly vary among study sections or among years.

The release of supplemental water from the reservoir has not improved the fitness of trout in the river. In addition, the condition of trout in the Tucker section was not deteriorated by the severe dewatering during 1985. Apparently, condition factors for rainbow trout and brown trout are not related to varying discharge in the river.

Growth Rates for Trout

The mean total length at time of capture and the back-calculated length at age for rainbow trout and brown trout collected during the Fall, 1984 are presented in Appendix C8 and C9, respectively. The growth increments of back-calculated length for rainbow trout averaged 81.2 mm (3.20 in) in the Darby section and 84.8 mm (3.34 in) in the Tucker section. For brown trout, the increments of back-calculated length averaged 91.6 mm (3.61 in) in the Darby section and 96.3 mm (3.79 in) in the Tucker section. Growth rates for both rainbow trout and brown trout appeared similar between sections. In addition, increments of growth for both species were similar between 1983 and 1984 (Table 12).

Growth rates apparently were not enhanced by the release of supplemental water from Painted Rocks Reservoir. The effects of dewatering on growth has not been fully assessed, however, since growth rates computed during 1983 and 1984 were obtained following several years of good summer flows. Analyses of age and growth for trout collected during the Fall, 1985 (following severe dewatering) have not been completed. Upon completion, these data will be compared to 1983 and 1984 data to more fully assess the effects of dewatering on growth rates of trout.

Tag Distributions and Preliminary Estimates of Harvest

Selected samples of trout captured while electrofishing were marked with individually numbered Floy tags to evaluate movements and to obtain an index of angler harvest. A total of 2,781 Floy tags has been distributed in trout in the Bitterroot River since

Table 11. Mean condition factors (K) for rainbow trout and brown trout greater than 127 mm (5 in) in total length from study sections of the Bitterroot River during 1982, 1983, 1984 and 1985. Standard deviations in parentheses.

		K					
SECTION	SPECIES	Fall 1982	Fall 1983	Spring 1984	Fall 1984	Spring 1985	Fall 1985
Darby	Rainbow trout	1.00	1.06	1.01	1.06	1.03	1.10
		(0.11)	(0.14)	(0.09)	(0.16)	(0.10)	(0.15)
	Brown trout		1.09	0.99	1.06	1.01	1.10
			(0.14)	(0.10)	(0.16)	(0.09)	(0.14)
Tucker	Rainbow trout		1.04	1.04	1.07	1.07	1.16
(E. Channel)			(0.09)	(0.11)	(0.13)	(0.10)	(0.16)
	Brown trout		1.02	1.00	1.04	1.01	1.11
			(0.09)	(0.09)	(0.12)	(0.11)	(0.13)
Tucker	Rainbow trout		1.04	1.02	1.06	1.02	1.13
(W. Channel)			(0.12)	(0.10)	(0.14)	(0.12)	(0.16)
	Brown trout		1.01	0.98	1.01	0.98	1.08
			(0.10)	(0.09)	(0.11)	(0.09)	(0.12)
Poker Joe	Rainbow trout						1.05
							(0.12)

Table 12. Growth increments of back-calculated length for rainbow trout and brown trout collected in the study sections of the Bitterroot River during 1983 and 1984.

	Mean increment of Annual Growth (mm)			
	Darby		Tucker	
Species	1983	1984	1983	1984
Rainbow trout	81.9	81.2	77.6	84.8
Brown trout	96.0	91.6	91.0	96.3

the inception of the study (Table 13). The species tagged included 1393 rainbow trout, 1314 brown trout, 58 cutthroat trout, 2 brook trout and 14 bull trout. A majority of these tags were distributed in the Darby, Tucker and Poker Joe sections.

Preliminary estimates of the harvest of tagged fish are presented in Table 14. Due to the poor compliance by anglers in returning tag information, harvest rates based on tag returns undoubtedly greatly underestimated actual harvest rates for trout in the Bitterroot River. Returns indicated only 2.2% of all marked rainbow trout and 3.2% of all marked brown trout were harvested by anglers. Harvest rates for rainbow trout were greatest in the reach of river located between Bell crossing and Stevensville. For brown trout, harvest rates were greatest between Como bridge and Hamilton. Information returned by anglers indicated 25% of the tagged rainbow trout and 12.5% of the tagged brown trout captured while fishing were released back into the river.

Evaluation of Movements from Tag Recoveries

The number of recoveries of tagged trout and the amount of time at large between marking and last recovery for fish recaptured by electrofishing in the Darby and Tucker sections are presented in Table 15. Tagged brown trout were recovered more frequently than rainbow trout. Approximately 24 and 38% of the brown trout tagged in the Darby and Tucker sections, respectively, were recovered at least once. For rainbow trout, about 20 and 22% of the number tagged in the Darby and Tucker sections, respectively, were recovered at least once. About 58% of all tagged fish recaptured by electrofishing were recovered more than once. Some of these fish were recovered as many as seven times.

The amount of time between marking and last recapture for trout tagged in the Darby section averaged 207 days (6.8 months). In the Tucker section, the amount of time at large for tag recoveries averaged 161 days (5.3 months). The average time at large was greater in the Darby section because the distribution of tags was begun earlier. Tag distributions were begun during the Fall, 1982 in the Darby section and during the Fall, 1983 in the Tucker section.

Movements made by tagged trout in the study sections are presented in Table 16. The distance and direction tagged fish moved appeared to be similar among study sections and between species. Of 266 rainbow trout relocations, 29 (10.9%) moved 2 km or more from their original tag site or previous recapture site. Of 502 brown trout relocations, 44 (8.8%) made movements of 2 km or more. The distance moved averaged 3.4 km (2.1 mi) for rainbow trout and 3.6 km (2.2 mi) for brown trout. Both species of trout exhibited more downstream movement than upstream movement. The farthest distance moved by a tagged fish recaptured by electrofishing was 35.6 km (22.1 mi) in a downstream direction.

Table 13. Distribution of tags for trout captured in the Bitterroot River from September, 1983 to November, 1985.

Location (km from mouth)	Number of Tags Distributed Rainbow trout	Brown trout	Cutthroat trout	Brook trout	Bull trout
Darby to Como bridge (126.0 - 115.0)	329	144	13	0	9
Como bridge to Hamilton (115.0 - 92.0)	61	24	2	0	1
Hamilton to Tucker (92.0 - 76.0)	98	124	1	0	0
Tucker to Bell (76.0 - 65.0)	531	843	24	2	4
Bell to Stevensville (65.0 - 53.0)	58	127	10	0	0
Stevensville to Florence (53.0 - 37.0)	313	48	8	0	0
Florence to Looking Glass (37.0 - 32.0)	3	4	0	0	0
TOTAL	1393	1314	58	2	14

Table 14. Tag distributions and preliminary estimates of angler harvest in the Bitterroot River as indicated by tag returns for the period from September, 1983 to November, 1985.

Location	Rainbow trout			Brown trout		
	Number Tagged	Number Harvested	% Harvested	Number Tagged	Number Harvested	% Harvested
Darby to Como	329	6	1.8	144	5	3.5
Como to Hamilton	61	2	3.3	24	2	8.3
Hamilton to Tucker	98	2	2.0	124	6	4.8
Tucker to Bell	531	13	2.4	843	26	3.1
Bell to Stevensville	58	6	10.3	127	2	1.6
Stevensville to Looking Glass	316	1	0.3	52	1	1.9
TOTAL	1393	30	2.2	1314	42	3.2

Table 15. The number of tagged fish recoveries and the mean number of days at large to last recovery for trout recaptured in the study sections of the Bitterroot River for the period September, 1983 to June, 1985.

			Recaptures				
		Total Number	Number[1] of		Number[2] of	DAL[3]	
Section	Species	Tagged	Tags	Percent	Relocations	Mean	Range
Darby	Rainbow	464	93	20.0	132	206	1-925
	Brown	254	60	23.6	103	208	1-706
Tucker East	Rainbow	238	59	24.8	85	132	2-560
	Brown	310	127	41.0	216	165	2-562
Tucker West	Rainbow	183	35	19.1	49	155	2-583
	Brown	317	112	35.3	183	176	2-596

1/ First recovery
2/ All recoveries including multiple relocations
3/ Number of days at large from mark to last recapture

Table 16. Movements of tagged trout in the Darby and Tucker sections which were recaptured by electrofishing[a/] during the period September, 1983 to June, 1985.

		Upstream Movement[b/]			Downstream Movement[b/]			No Movement
		Number	Distance Moved (km)		Number	Distance Moved (km)		Number
Section	Species	of fish	Mean	Range	of fish	Mean	Range	of fish
Darby	Rainbow	4	3.3	2.3-5.0	8	3.5	2.0-7.2	120
	Brown	5	3.0	2.3-4.2	6	3.3	2.4-4.6	92
Tucker East	Rainbow	3	4.0	3.5-4.3	7	3.3	2.0-4.5	75
	Brown	8	3.5	2.0-5.5	8	3.6	2.0-5.5	200
Tucker West	Rainbow	1	2.1		6	4.6	2.7-7.4	42
	Brown	5	4.5	2.6-8.2	12	3.2	2.1-4.7	166
Total	Rainbow	8	3.4	2.1-5.0	21	3.7	2.0-7.4	237
	Brown	18	3.6	2.0-8.2	26	3.4	2.0-5.5	458

a/ Includes multiple relocations. Movements were measured between consecutive recapture sites.

b/ Movement $\geq$ 2.0 km

This movement was made by a rainbow trout that had been tagged in the Darby section. The farthest distance moved by a tagged fish recaptured by angling was 95.1 km (59.1 mi). This movement was made by a brown trout tagged near the Tucker section and recaptured in the Clark Fork River near Frenchtown.

Movements made by most trout appeared to be unrelated to spawning behavior. A majority of marked fish remained within 2 km (1.2 km) of their original tag site or subsequent relocation site. However, several tag recoveries for both species indicated an association between their movements and spawning behavior. These were sexually mature fish that made substantial movements in an upstream direction during their spawning season. Some spawning migration undoubtedly does occur in the river and tributaries but is difficult to document based solely on tag recoveries.

Trout did not appear to move out from the dewatered reach as flows became severely depleted during 1985. Congregations of trout, some with tags, were visually observed in the remaining pools within the dewatered reach when flows became critically low in July. Although not documented, trout also may have migrated into the ditch systems during the low flow period. Further evaluation is needed to determine the extent of ditch use by fish during low flow conditions in the Bitterroot River.

Minimum Flow Recommendations

Instream Flow Needs for Trout

Recommendations for instream flows needed to maintain trout populations in the Bitterroot River were determined using the wetted perimeter/inflection point methodology. During 1985, this methodology was applied to two riffles located near Hamilton, two riffles located in the east channel of the Tucker section, two riffles located in the west channel of the Tucker section and three riffles located downstream from Stevensville (Figure 1). The riffles surveyed near Hamilton and in the Tucker section were located within the dewatered reach of the river. The riffles surveyed downstream from Stevensville were located in the reach of river that is rewatered by irrigation returns.

Wetted perimeter-discharge relationships obtained from the two riffles near Hamilton, based on a composite of three cross-sections for each riffle, are presented in Appendix D1 and D2. The upper inflection points from these relationships were chosen as recommendations for instream flows because discharge values associated with the lower inflection points were substantially less than the 10.6 m^3/sec (375 ft^3/sec) recommendation derived from analysis of 2 riffles during 1984. The upper inflection point for both riffles surveyed near Hamilton was 12.7 m^3 (450 ft^3/sec). This flow recommendation for the dewatered reach is 2.1m^3/sec (75 ft^3/sec) greater than the recommendation derived during 1984.

Wetted perimeter-discharge relationships obtained from riffles in the east and west channels of the Tucker section, based on a composite of three cross-sections for each riffle, are presented in Appendix D3 and D4, respectively. Discharge values associated with inflection points derived from riffles in the east channel averaged 4.95 m^3/sec (175 ft^3/sec). In the west channel, discharge values associated with inflection points averaged 5.10 m^3/sec (180 ft^3/sec). A flow of 10.1 m^3/sec (355 ft^3/sec), the sum of the recommendations derived for each channel, appears to be needed to maintain trout populations in the Tucker section.

A summary of instream flow recommendations derived from riffles within the dewatered reach of the river is presented in Table 17. Recommendations have ranged from 9.2 m^3/sec (325 ft^3/sec) to 12.7 m^3/sec (450 ft^3/sec). A flow of 11.35 m^3/sec (400 ft^3/sec), an average of all derived recommendations, appears to be necessary for the maintenance of riffle habitat with the dewatered reach of the river. However, this minimum flow is seldom met during the summer and fall due to substantial irrigation withdrawals. As a result, supplemental water purchased from Painted Rocks Reservoir should be managed in a manner which would meet this minimum flow recommendation for the greatest possible amount of time.

A management plan for purchased water from the reservoir was formulated in 1984 to maximize the amount of time that a 10.62 m^3/sec (375 ft^3/sec) flow would be met at Bell crossing (Lere 1984). In the management plan, 15,000 AF of supplemental water was predicted to be able to maintain this target flow for approximately 53% of the time. Obviously, recommended flows for the dewatered reach cannot be met during low water years. During extremely dry years, as in 1985, supplemental reservoir water would be able to maintain only a trickle between pools unless releases could be protected from appropriation by irrigation systems.

Wetted perimeter-discharge relationships and associated inflection points obtained from the three riffles located downstream from Stevensville are presented in Appendix D5, D6 and D7. A flow of 8.5 m^3/sec (300 ft^3/sec), the average of the three composite inflection points, appears to be necessary for the maintenance of rifle habitat in this rewatered reach of river. This recommendation is less than the 11.35 m^3/sec (400 ft^3/sec) recommendation derived for the dewatered reach. This contrast may be due to differences in channel morphology between reaches. The channel in the dewatered section of river is unstable and, as a result, is abnormally wide with poorly defined stream banks. In comparison, the channel in the rewatered reach is relatively stable. Because of this greater stability, the rewatered reach apparently requires lower flows to maintain riffle habitat than the dewatered reach.

Table 17. Summary of instream flow recommendations derived from riffles within the dewatered reach of the Bitterroot River.

Year	Location of riffle	Instream Flow Recommendation m^3/sec	Instream Flow Recommendation ft^3/sec
1984	Bell crossing (1 km upstream)	9.20	325
1984	Bell crossing (2 km downstream)	12.04	425
1985	Hamilton (at North bridge)	12.70	450
1985	Hamilton (1/2 km below Blodgett)	12.70	450
1985	Tucker[a/] (East & West Channel)	10.10	355
	AVERAGE	11.35	401

a/ Recommendations summed for east and west channels.

An 8.5 m^3/sec (300 ft^3/sec) flow recommendation for the rewatered reach is substantially less than the median monthly flows (April through October) derived from 12 years of record at the DNRC station near Stevensville. The median values for the low flow months of August, September, and October are 19.7, 20.7, and 23.7 m^3/sec (697, 730 and 836 ft^3/sec), respectively. August flows at the DNRC station averaged less than the 8.5 m^3/sec (300 ft^3/sec) recommendation in only 2 of the 12 years on record. Apparently, reservoir water would seldom be needed to supplement flows within the rewatered reach of the river.

Recreational Floating Requirements

The minimum depth and width of water required to allow passage of drift boats and rafts, crafts commonly used on the Bitterroot River, is 0.3 m (1.0 ft) and 1.8 m (6.0 ft), respectively (Hyra 1978). Analyses of wetted perimeter transects established in the dewatered section of river indicated that a flow of 4.25 m^3/sec (150 ft^3/sec) would be needed to provide the criteria to float drift boats and rafts over the shallow riffle areas. This level of flow would allow boats to pass over 17 of the 18 cross-sections that were evaluated. In the reach of river located downstream from Stevensville, this same flow level would provide the minimum floating criteria for all three of the riffles that were evaluated.

CONCLUSIONS AND RECOMMENDATIONS

Cooperation by main stem irrigation companies appears to be the most important avenue for maintaining adequate flows within the dewatered section of the Bitterroot River. Without this cooperation, a majority of the supplemental water released from Painted Rocks Reservoir will be appropriated into the irrigation systems before reaching Bell crossing. To protect supplemental releases from appropriation, irrigators would have to voluntarily adjust diversion headgates or, as in 1985, would have to agree to appoint a water commissioner.

The water management plan developed during this study was designed to release purchased water from the reservoir in a conservative manner to insure that supplemental water would be available for the entire irrigation season. Historical flow records indicate dewatering in the Bitterroot River may occur as early as July or as late as September. A conservative approach is necessary because the timing and duration of dewatering in the river cannot be predicted. However, main stem irrigators have indicated that their water needs are greatest during July. They also have indicated a willingness to lower diversion headgates during September if a greater portion of the purchased water was released earlier in the irrigation season.

In an attempt to provide optimum benefits to the river, a cooperative agreement has been tentatively reached in which MDFWP would give 3,000 AF of purchased water annually to the main stem irrigators to use as necessary. In return, irrigators would lower headgates during the last half of September if flows fell below minimum recommendations and would agree not to oppose the appointment of a water commissioner to insure that a substantial percentage of the purchased water released from the reservoir remained instream. It is recommended that MDFWP continue to pursue this cooperative agreement and to evaluate its effectiveness in improving the Bitterroot fishery.

Supplemental releases from the reservoir have not substantially reduced the need to channelize or dike the river to obtain irrigation water. Distribution of water within this multi-channeled and unstable river appears to be more of a problem to irrigators than water quantity. Augmenting flow in an inappropriate river channel provides little assistance to the main stem irrigators. It is therefore recommended that MDFWP provide technical assistance to the irrigators for improving headgate location and design. In addition, methods for stabilizing the stream channel should be evaluated and techniques proven successful should be incorporated into any improvement plan.

Supplemental releases appear to be enhancing the rainbow trout population in the upper Bitterroot River. In the dewatered section, the potential for enhancement of the fisheries may be

significantly reduced due to the appropriation of supplemental water into the irrigation systems. If purchased water can be protected from diversion, the potential for enhancement could be significantly increased. Poor recruitment of young of the year fish into the population appeared to be responsible for the suppressed numbers of rainbow trout in the dewatered section. Supplemental water, if protected, could improve the rearing areas used by these young fish. It is recommended that the present study should attempt to more fully evaluate the effect of dewatering on rearing trout in the Bitterroot River and should attempt to quantify the instream flows needed to maintain this rearing habitat.

Releases of supplemental water do not appear to be enhancing adult brown trout populations in the Bitterroot River. If supplemental releases were protected from appropriation, however, the potential for enhancement in the dewatered section could be significantly increased. In the upper reach of river, the brown trout population may be limited by the quantity of shoreline and instream cover that is present. Several studies have demonstrated the importance of cover for determining the carrying capacity of trout populations. (Boussu 19854, Hunt 19876).

Discharge and trout populations should continue to be monitored in the control and dewatered sections in order to maintain the appropriate release schedule for supplemental water and to evaluate the effectiveness of water releases for enhancing the fishery in the river. Finally, if supplemental water cannot be insured to remain instream with the use of a cooperative agreement among water users, it is recommended that water purchases from Painted Rocks Reservoir be discontinued.

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APPENDIX A

Discharge Data for the Bitterroot River and Major Diversions

Appendix A1. Mean daily flows (ft^3/sec) recorded at the Hamilton, Woodside, Bell and Poker Joe stations on the Bitterroot River during 1985.

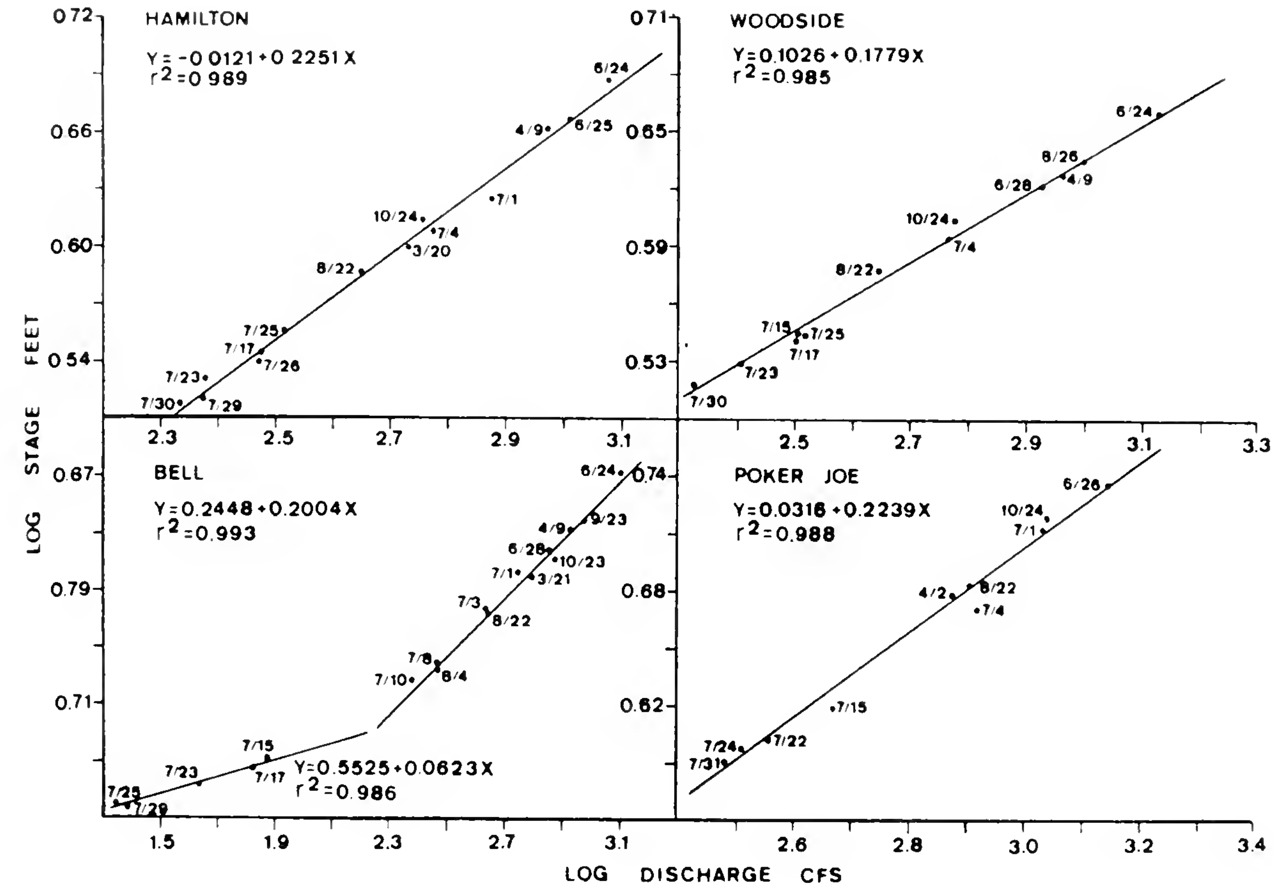
	June				July			
Day	Hamilton	Woodside	Bell	Poker Joe	Hamilton	Woodside	Bell	Poker Joe
1					630	695	588	1064
2					579	635	501	925
3					529	596	439	872
4					517	563	376	729
5					526	539	344	655
6					498	512	325	622
7					458	473	305	598
8					440	451	291	565
9					387	413	266	503
10					341	393	250	459
11					309	343	230	425
12					308	330	220	408
13					332	330	199	396
14					313	325	99	386
15					306	305	75	402
16					294	296	65	401
17					295	277	62	402
18					295	263	58	397
19					277	251	51	397
20					275	236	38	364
21	2050	2496	2010		260	225	38	364
22	1693	1975	1725		236	222	38	358
23	1520	1770	1540		253	234	37	346
24	1309	1533	1357	2043	274	274	27	341
25	1054	1313	1182	1748	316	310	26	357
26	899	1084	993	1458	315	306	26	359
27	799	891	813	1259	262	255	25	359
28	736	822	712	1162	249	234	24	341
29	699	766	668	1154	248	237	24	343
30	669	716	625	1069	246	246	24	327
31					268	267	25	316
MEAN	1143	1337	1163	1413	350	356	164	477

Appendix A1 - continued

	August				September			
Day	Hamilton	Woodside	Bell	Poker Joe	Hamilton	Woodside	Bell	Poker Joe
1	298	270	30	330	305	291	230	483
2	325	339	67	417	315	291	232	487
3	468	481	227	514	311	291	225	492
4	473	462	293	627	319	286	225	478
5	465	445	319	712	334	313	230	472
6	441	421	332	712	316	312	286	687
7	441	388	313	640	377	390	423	967
8	385	356	301	627	557	437	540	1190
9	362	354	284	582	727		715	1404
10	378	387	300	594	891		840	1593
11	518	488	388	739	805		890	1690
12	552	519	477	924	1046		1147	2167
13	669	529	551	1083	1170		1467	
14	604	532	565	1079	920		1238	2480
15	537	529	524	965	979		1275	2518
16	522	529	520	939	1002	1034	1344	
17	505	529	490	878	965	1052	1214	
18	457	529	461	809	1111	1175	1216	2021
19	483	529	457	722	1033	1121	1151	1946
20	494	529	473	789	952	1013	1089	1747
21	497	529	471	843	863	933	1010	1599
22	442	487	427	785	878	940	993	1612
23	433	445	404	753	824	888	943	1542
24	416	443	364	717	715	755	846	1407
25	389	439	328	684	627	679	740	1244
26	415	421	309	647	580	627	671	1125
27	430	403	294	591	578	602	641	1087
28	340	340	285	546	556	602	611	1029
29	293	280	260	491	538	602	584	987
30	308	278	253	472	534	602	572	965
31	304	267	228	482				
MEAN	440	435	355	700	704	662	786	1312

Appendix A1 - (continued)

	October				November			
Day	Hamilton	Woodside	Bell	Poker Joe	Hamilton	Woodside	Bell	Poker Joe
1	530	602	595	992	651	785	744	1294
2	541	581	598	992	731	866	789	1337
3	537	585	620	1047	880	1042	933	1560
4	596	657	655	1085	840	1021	963	1621
5	558	613	634	1067	888	1065	1007	1629
6	532	613	620	1037	819	981	978	1612
7	596	683	674	1170	784	928	907	1513
8	572	692	701	1187	748	839	863	1459
9	503	672	632	1081	677	741	818	1409
10	521	657	617	1043	565	679	716	1203
11	553	657	651	1058	528		659	1019
12	552	635	666	1058	492		599	964
13	533	613	650	1058	481		586	984
14	510	589	630	1020	511		598	951
15	514	613	615	992	567		629	982
16	559	649	658	1103	662		703	1167
17	580	603	668	1153	656		746	1253
18	562	622	638	1103	576		680	1144
19	533	657	612	1077	520		599	1134
20	525	657	618	1074			592	
21	529	618	641	1083			577	
22	571	654	657	1102			559	
23	591	705	692	1195				
24	591	676	666	1178				
25	692	721	654	1184				
26	1012	1181	1032	1717				
27	881	1034	978	1702				
28	852	991	912	1594				
29	780	959	856	1508				
30	716	893	787	1405				
31	683	831	749	1323				
MEAN	607	707	690	1174	662	895	738	1276



Appendix A2. Stage-discharge rating curves derived for temporary gauging stations on the Bitterroot River during 1985.

Appendix A3. Mean daily flows recorded at stations on the Hedge, Republican, Corvallis, Supply and Webfoot diversions during 1985.

	April					May				
Day	Hedge	Republican[a]	Corvallis	Supply	Webfoot	Hedge	Republican[a]	Corvallis	Supply	Webfoot
1			2		70			102	11	127
2	4		2		76			113	11	146
3	4		2	27	83			118	33	157
4	4		2	27	85			118	68	159
5	4		2	26	79			97	60	130
6	4		2	25	79			71	74	116
7	4		2	25	79			71	86	175
8	4		2	26	80	110		114	148	212
9	4		1	26	89	104		130	151	201
10	3		1	28	104	104		126	137	183
11	4		2	26	120	103		122	130	168
12	3		1	22	108	102		122	125	164
13	3		1	22	106	102		97	148	171
14	3		8	22	101	90		77	156	170
15	3		10	23	123	89		140	181	159
16	3		9	22	135	89		152	181	173
17	3		9	19	136	89		170	178	182
18	3		9	18	133	89		184	191	190
19	3		9	18	123	90		193		190
20	3		9	17	105	81		205		195
21	3		8	15	90	75		221		203
22	3		8	15	85	72		232		206
23	6		8	15	82	71		225		203
24	10		8	15	78	71	164	164		206
25	15		46	14	72	69		111		193
26	16		73	14	68	69		96		173
27	17		71	13	66	69		85		159
28	25		76	13	68	70		85		161
29	72		83	13	73	70	153	81	190	159
30			89	13	44	69		74	177	153
31						67		69	141	133
MEAN	8	—	19	20	91	84	159	128	123	172

Appendix A3 - (continued)

Day	June					July				
	Hedge	Republican[a]	Corvallis	Supply	Webfoot	Hedge	Republican[a]	Corvallis	Supply	Webfoot
1	67		68	131	129	114		69	186	120
2	69			141	141	115		69	257	103
3	69			131	125	115		65	239	173
4	70			144	124	115		61	231	164
5	70			155	127	115		65	215	149
6	72			164	139	118		61	207	138
7	73	175		177	155	119		59	207	131
8	75			152	160	124		60	207	125
9	74			141	131	126	106	64	200	99
10	73			124	139	126		65	182	80
11	72			117	162	126	179	61	163	68
12	73	153	80	128	147	128		61	157	67
13	74		78	196	143	129		64	166	174
14	75		77	235	202	130		63	160	172
15	75		77	244	294	130		59	160	184
16	76		77	238	286	110		61	157	216
17	76		73	227	259	135		60	154	154
18	80		72	211	236	135	153	58	154	128
19	90		72	203	227	135		58	154	115
20	91		73	211	227	133		55	149	110
21	91		74	200	207	133		55	143	99
22	91		78	182	184	132		55	143	104
23	101		78	179	167	132	129	53	146	102
24	105	170	76	166	151	135		57	153	116
25	105		61	154	131	133	161	58	165	147
26	105		62	146	145	130		58	173	141
27	106	161	62	134	145	128		49	155	110
28	107		73	120	144	128		49	152	103
29	108		73	118	138	128	112	49	155	103
30	108		71	114	132	129		51	152	103
31						130		53	160	102
MEAN	84	165	73	166	170	126	140	59	174	126

Appendix A3 - (continued)

Day	August: Hedge	Republican[a]	Corvallis	Supply	Webfoot	September: Hedge	Republican[a]	Corvallis	Supply	Webfoot
1	128		51	167	105	125		42	93	
2	132		52	183	129	125		42	83	
3	135		53	108	137	125		40	83	
4	120	138	50	93	125	125		38	79	
5	129		49	91	83	126		37	77	
6	128		47	86	62	128		42	87	
7	128		44	86	59	122		44	60	
8	128		37	82	57	116		48	60	
9	128		39	82	59	116		49	60	
10	129		46	84	64	117		48	60	
11	131		47	79	75	104		47	60	
12	132		47	80	78	91		49	40	
13	131		36	66	82	91		46	40	
14	129	125	30	61	79	89		46	40	
15	129		26	60	76	89		36	40	
16	129		15	60	75	89	96	19	40	49
17	129		15	60	74	90		18	40	
18	129		15	60	118	7[b]		17	40	
19	129		15	55	140	7[b]		16	40	
20	129		15	51	132	7[b]		15	36	
21	128		16	53	125	7[b]		15	34	
22	125		15	51	115	7[b]		15	34	
23	125		14	47	198	7[b]	52	15	38	65
24	125		13	45	193	7[b]		15	39	
25	125		13	62	193	7[b]		31	39	
26	126	111	13	86	188	7[b]		38	39	
27	125		13	78	188	7[b]		39	39	
28	125		12	63	176	7[b]		38	39	
29	124		12	63	165	7[b]		37	39	
30	124		11	76	152	7[b]		36	39	
31	125		41	93	144					
MEAN	128	125	29	78	118	65	74	34	51	57

Appendix A3 - (continued)

Day	October Hedge	Republican a/	Corvallis	Supply	Webfoot
1			36	39	
2			36	39	
3	7	1	40	36	72
4	7		41	33	
5	6		41	33	
6	6		41	33	
7	6		44	33	
8	6		41	33	
9	5		40	33	
10	5		39	33	
11	5		41	33	
12	5		41	33	
13	5		40	33	
14	5		38	32	
15	5		38	28	
16	5		40	33	
17	4		40	30	
18	5		38	33	
19	4		38	30	
20	5		38	33	
21	5		38	33	
22	5		38	33	
23	5	1	40	32	68
24	5		39	28	
25	5		40	27	
26	5		42	31	
27	4		42	31	
28	4		42	31	
29	4		42	31	
30	4		40	31	
31	4		39	31	
MEAN	5	1	40	32	70

a/ Flows determined from staff ga. readings
b/ Estimation

Appendix A4. Stage-discharge regression equations developed for the Hedge, Republican, Corvallis, Supply and Webfoot diversions during 1985.

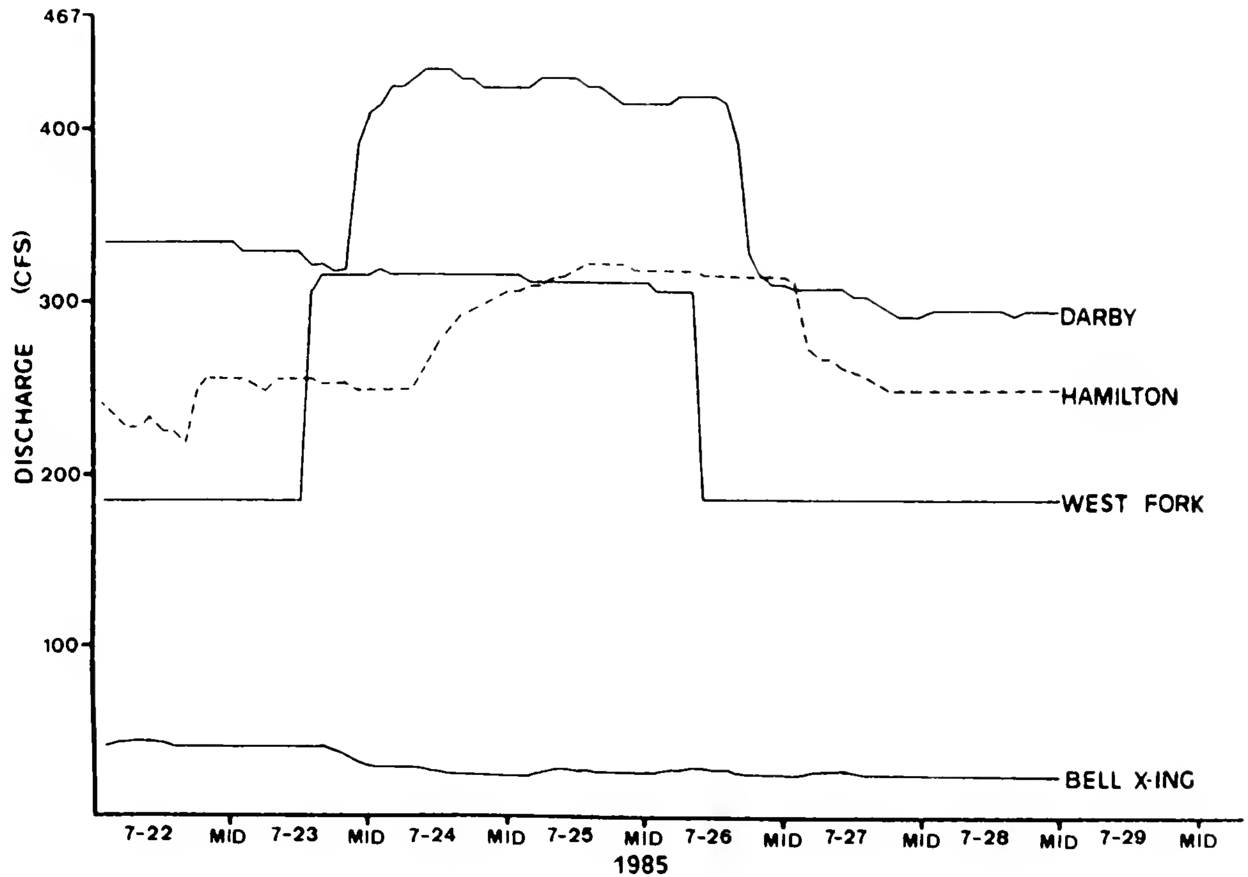
Ditch	Time Period	Regression Equation	N	Correlation Coefficient r
Hedge	4/2-4/25, 10/3-11/4 (Low Flow)	y=1.7268+0.0508X	4	0.92
	5/8-6/11 (Pre-Algae)	y=1.5174+0.1988X	3	0.81
	6/12-7/15 (Algae)	y=1.1200+0.4118X	3	0.95
	7/16-9/17 (Bulldozed, Post-Algae)	y=1.4411+0.2500X	3	0.96
Republican	5/24-10/23 (Total)	y=0.8381+0.1176X	6	0.99
Corvallis	4/14-6/24, 8/31-11/4 (Algae-free)	y=1.6816+0.1116X	6	0.99
	6/25-8/30 (Algae)	y=1.7107+0.1151X	5	0.99
Supply	4/13-5/3, 8/13-8/27, 9/7-11/4 (Low Flow)	y=1.7398+0.0558X	5	0.99
	5/4-5/7, 8/4-8/12, 8/28-9/6 (Intermediate Flow)	y=1.6940+0.0879X	11	0.99
	5/8-8/3 (High Flow)	y=1.6606=0.1037X	6	0.85
Webfoot	5/1-11/4 (Total)	y=1.3498+0.1863X	10	0.97

where y = log stage (inches)[a/]
X = log discharge (ft^3/sec)

a/ Republican stage in feet

Appendix A5. Chronology of management operations on the Hedge, Corvallis, Supply and Webfoot diversions during 1985.

DITCH	ADJUSTMENTS MADE	DATES (ALTERATION MADE)
Hedge	Headgates Raised	4/23, 4/29, 6/18, 7/8, 8/4
	Headgates Lowered	5/14, 5/20, 8/4, 9/8, 9/11, 9/12, 9/17
	Channel Alterations	7/16 - Scraped algae in ditch channel
Corvallis	Headgates Raised	4/25, 4/29, 5/8, 5/15, 6/25, 8/31, 9/25
	Headgates Lowered	5/6, 5/14, 5/25, 8/13, 8/15, 9/16
	Channel Alterations	7/7 (?) - Added planks to dam
Supply	Headgates Raised	5/3, 5/6, 5/8, 5/15, 6/13, 7/1?, 8/30
	Headgates Lowered	8/3, 8/12, 9/7, 9/12
	Channel Alterations	7/1(?) - Diked west channel
Webfoot	Headgates Raised	4/30, 5/7, 6/10, 6/14, 7/3?, 7/13?, 8/18
	Headgates Lowered	8/5, 9/2
	Channel Alterations	4/30 - Removed gravel from ditch channel 7/3 - Diked river in front of diversion 7/13 - Diked west channel



Appendix A6. Hydrographs derived at gauging stations on the Bitterroot River during a test release of water from Painted Rocks Reservoir conducted in July, 1985.

APPENDIX B

Daily Maximum and Minimum Water Temperatures Recorded during 1985

Appendix B1. Daily maximum and minimum water temperatures (^{o}F) recorded at the Darby, Hamilton, Bell and Maclay stations on the Bitterroot River during 1985.

	MARCH								APRIL							
	Darby		Hamilton		Bell		Maclay		Darby		Hamilton		Bell		Maclay	
Day	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1									46	37	50.5	41	51	42	50	45
2									45.5	37	51	43	52	43	52	47
3									43	36.5	47	42.5	49	43.5	50	48
4									42.5	36	45.5	40	46	41	48	46
5									47	37	47	41	49	42	49	45
6		32.5		33					46	36	50	40	50	40.5	49	46
7	36	32.5	39	32	40				47	37	49	41	50.5	42	49	46.5
8	36	32.5	39	32	41	34			50	41	50	42	48	44	48	47
9	36	32.5	40.5	32	41	34			49	39	52	43	53.5	44	50	46
10	36	32.5	41	33.5	41	35			47.5	39	51.5	43	52.5	45	51	49
11	36	32.5	40	33	41.5	35	42.5		44.5	41	47	43	49	46	51	49
12	36	32.5	41	33.5	42	35	43	39	48	39	49	40.5	50	42	50	46.5
13	37	32.5	41.5	34	43	35	44	39	48.5	39.5	50	41.5	51	43	50	47
14	37	32.5	42.5	34.5	43.5	36	44.5	40	49	40	50	42	51	44	50.5	47
15	37.5	32.5	42.5	35.5	44	37	45	41	46	40.5	46	42	47	44	50.5	46.5
16	38	32.5	42.5	35.5	44	36.5	45	41	46	40	47	41	47	42.5	48	45
17	38.5	32.5	44	36	45	37	46	41	46.5	40.5	48	41.5	49	43	49.5	46
18	39	33	45	37	46	38	46	42	46	41	46.5	41.5	47	43	49.5	46
19	39	32.5	44	36.5	45.5	38	46	42	44	40	44	40	45	42.5	48	45
20	38	33.5	43	38	43	39	45	43.5	41.5	37	43	37	45	40	45	42.5
21	37.5	34	41	37	43	38	43.5	42	43	35	43	36	45.5	38	45	42
22	38	32.5	41	35.5	42.5	37	43	41	44	36.5	44.5	38	46.5	40	46	43
23	39	33	42	36	42.5	38	45	42	43	39	43	39	46	41.5	46	44.5
24	37	35	41	39	42	40	44	42.5	44	37	46.5	37	46.5	39	46	43
25	41	32.5	43	35	44	37.5	44.5	41	44	36	44	37	47	40.5	46.5	44
26	39.5	34	43	36.5	44	38	45	41	46	38	46	39	48	41	47.5	46
27	39	34	41	36.5	43	38.5	44	42	54.5	42	54	43	54	44	52.5	47
28	41	32.5	42.5	34.5	44	37	45	40.5	52.5	43	54	45	55	47	53.5	51
29	41.5	34	42	37	44	38	44	42	53	45	54	47.5	56	49	55	53
30	40	34	42.5	37	44	38	44	42	52	42.5	52	45	54.5	47	55	52
31	40	36	45.5	39.5	44	40.5	45	43								

Apendix B1 - (continued)

	MAY								JUNE							
	Darby		Hamilton		Bell		Maclay		Darby		Hamilton		Bell		Maclay	
Day	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	51	43	51.5	45	53	46	54.5	51	49	45	54	48.5	56	50	55	51
2	49	43	50	44	51	46	54	49	50	44	50	46	51	47	55	49
3	47.5	42	47.5	43	50	44	52	48	54	45	55	47	56	47.5	55.5	49.5
4	46	40	45	40.5	45	42	51	45	51	46	53	49	54	50	55.5	52
5	48	39.5	48	40	49	41	49	44	50	47	51.5	49	52	50	54	51.5
6	49	40	50	41.5	49.5	43	50.5	46	52.5	46	54	48	53	49	52.5	50
7	49	41.5	49	44	51	45	51	48	53	47	54	48.5	56	50	56	52
8	47	42	49	45	50	46	51	48	53	46.5	55	49	56	50	56	51
9	45	41.5	47	44	47	45	49.5	46.5	53	45	55	48	56	49.5	55	50.5
10	45	40	47.5	42.5	48.5	43.5	49	45	55	44.5	56	48	57.5	49.5	56	51
11	47	41	49	43	50.5	44	49.5	46	56	46	57.5	49	59	50.5	58	52
12	48	38	48	40.5	50	42	49.5	45	56	48	57	51	57.5	52	58	53.5
13	50	39	51	42	53	43	52	46	53	49	55	52	56	52.5	57	53
14	46	41.5	48	45	51	46.5	52	48.5	57	48	58	50.5	59	51.5	57.5	52.5
15	52.5	42	53	44	55	45	55	49	59	49	60	52.5	62	53	60	55
16	53	43	54	47	55.5	47	56	51.5	59	49.5	61	53	62	53.5	60.5	55.5
17	52	42	53.5	46	55	48	56	52	60	49	61	53	62	54	60.5	56
18	53	42.5	53.5	46	55	47.5	56	51	61	49.5	62	54	64	54	61.5	56.5
19	50	43	51	46	52	48	55.5	51	62	51	64	55	65	55	62.5	58
20	50	44	52	46	54	47	54	49	61	52.5	63	56	64	56.5	63	59
21	52	43	53	46	54	46.5	54.5	49	60	50	63	54	64	55	63	58
22	53	44	53	47	55	48	55	50	61.5	51	64	55	65	56	64	59
23	52	45	54	48	54.5	49	55	50.5	61.5	51	65	55	66	56	64	60
24	51	45	53.5	47	54	49	55	51	58	51	62	54	64	55.5	63	60
25	50	46	53	48	53.5	48	55	50	55	50	60.5	53	63	55	61.5	58
26	50	45	52	47	53	48	54	50	60	47	63	51	65	54	63	58
27	52	46	54	48	55	49	55	50	61	50	65	54	67	56	64.5	60.5
28	50	46	52	48	53	50	55	51.5	63	52	66	56	68	58	65	62
29	48	45	50	46.5	50	48	53	50	62	53	67	57.5	68	59	66	63.5
30	46	43.5	47	45	48.5	46	50	47	63	53	68	57	69	59	66.5	63
31	53	43	54	44	54	45.5	54	47								

Appendix B1 - (continued)

	JULY								AUGUST							
	Darby		Hamilton		Bell		Maclay		Darby		Hamilton		Bell		Maclay	
Day	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	65	54	69.5	58	70	59	67	64	62	56	69	62.5	64	57	69	64.5
2	65	54.5	69.5	59	70	60	67.5	65	57	54	64.5	59	59.5	58	66.5	61
3	67	56	71	60	70.5	60	69	65	63	53	67	57	68.5	58.5	67	60
4	66	56.5	70	60.5	69	61	69	65.5	64	54.5	71	60	70	61	68.5	64
5	68	57	72	61	71.5	62	70	66	65	55	71	60	71.5	61.5	69	65
6	68	58	72.5	61.5	71	62	70	66	64.5	54	70	60	71	61	69	64.5
7	66	58	69	62	69	63	68.5	66.5	64	54	70.5	60	70	61	68	64
8	67	57	72	61	69	61	68.5	65	59.5	56	63	60	67	61.5	66	63.5
9	69	59	74	63	73	63	70.5	65	63	53	67	57	68	58	64.5	62
10	69	60	74	64	73	64	72	67	58	53.5	63	58	64	59	64	59
11	67.5	60	72	63	71	63	71	67	56	52	57.5	55	59.5	57	59	57.5
12	63	59	71.5	62	71	62	70	65.5	55	52	56.5	55	59	56	59	58
13	66	55.5	71.5	60	70	61	70	64.5	60	51	63	54	65	55	62	56
14	66	55	71.5	60	69	60	70	64	62	52	65	56	66.5	57	64	60
15	66.5	56	72	60	69	60	70	65	61	54.5	64	58	64	60	64	61.5
16	65.5	57	72.5	61	69	60.5	71	65	62	54	65	56.5	65.5	58	63	59
17	66	57	72	62.5	69	61	71	66	63	52.5	66.5	56	67	57.5	64.5	60
18	66.5	56.5	72	61	69	60	70	64	63	54.5	67	58	68	59	66	62
19	66	56	72	60	68	60	70.5	65	61	56	66	59	67	60.5	66	63.5
20	66	56	72	60	66.5	58	71	65	61	54	64	57.5	65	59.5	65	62.5
21	66	56	72	61	66	58	71.5	65.5	62	55	64	57.5	64.5	59	64	61
22	65	57	71	62	65	58.5	69.5	66	63	54.5	66	57	66	58	63	60.5
23	66.5	57.5	72	62	66.5	57	70	65	63.5	53	66.5	56	67	58	65	60.5
24	64.5	55	72	62	61	55	70.5	65	65	55	68	57.5	68	59	66	62
25	64	52.5	71	60	62	55.5	70.5	64.5	62	56	66.5	59	68	60	66	63
26	65	54	70	60	61	55.5	70	65	64	56	67	59	68	60	66	63
27	67	56	71	60	62.5	56	70	65	65	56	68	60	69	60.5	67	63
28	62.5	57	68.5	60	59	56	69	64.5	65.5	57	70	60	69	61	68	63
29	66	55	71	60	62	56	69	63.5	65	56	69	59	68.5	59	67	63
30	61	56.5	69	61.5	59	56	67.5	64	66	57.5	69	60	67.5	60	66	62.5
31	65	55	72	61	62	56	70	63.5	63.5	55.5	67	58	66.5	59	65	61.5

Appendix Bl - (continued)

	SEPTEMBER								OCTOBER							
	Darby		Hamilton		Bell		Maclay		Darby		Hamilton		Bell		Maclay	
Day	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	61	53	64	55.5	65	56.5	63.5	59.5	45	41	46	43.5	48.5	46	49	48
2	60	56	64	57	64	58	62	59	47.5	43	49	44	50	46	49	47
3	62.5	54	65	56	65	57	64	60	52	46	53	47.5	54	49	52.5	49
4	63.5	54	66	56	66	57	65	60	48	41.5	51	45	53	47	51	49
5	60.5	57	63	59.5	62	59	63	60	50	43	52	45.5	53.5	47.5	51.5	49.5
6	60	57	61	58	60	57	60	57.5	49	46	51	48	52	50	51.5	50
7	57	54.5	58	55	58	55	57	56	47	38	49.5	41	49	42.5	50	45.5
8	60	53	60	54.5	61	55	59	55.5	40	36	41	38	45	40.5	45.5	42
9	58	55	58	56	59	56.5	58	57	41	34	42	35.5	45	39	44	40.5
10	61	54	62	54	63	55	60	56.5	44	36	44	38	47	41	45	43
11	60	54	61	55	61	56	60	59	45	40	46	41	48.5	44	47	45
12	57	53	58	55	58.5	55	60	56.5	44	40.5	46	42.5	50	45	47.5	47
13	56	49.5	58	51	59	52	58	55	45.5	41	48	43	50	45	48.5	47
14	59	52	59	53	59	54	59	56.5	44	41	46	44	43	46.5	48	47.5
15	56	52	58	53	58.5	54	58	56	49.5	43	50	45	52	47	51	47.5
16	53	48	54	50	55	51.5	57	53.5	45	42	47	45	48.5	46	51	48
17	54	50	54.5	51	55.5	52	55	53	46	40	48	43	51	45.5	49	47
18	52	47	53	49	55	50	54.5	52.5	46	40	47.5	42	50	44	49	47
19	52	47	53	49	54	50	54	52	46	41	49	42.5	49.5	44.5	48	46.5
20	54	45	55	47.5	56	49	54	51	47	42	47	44	49	46	49	47.5
21	53	50	54.5	52	55	53	55	54	45.5	42	46	44	48	45.5	49	47.5
22	54	48	56	49	57	51	55.5	53	44	40.5	45	42	47	44	47.5	46
23	51	44.5	53	47	55	49	53.5	53	43.5	41	44	42	46.5	44	46	45
24	53	48	55	50	57	51	54	52	45	40	47	42	48.5	44.5	47	45
25	53	45	55	48	57	50	55	52	47	43.5	49	45	50	47.5	49	47
26	54	46	56	48.5	57	50	55	52.5	46	41	46	42	47.5	44	49	46
27	50	44	53	47	53	47	54	50	46	41	48.5	43	49.5	45	47.5	45
28	47.5	42	50	43.5	52	40	50	47	43	39	46.5	41.5	47.5	43	47.5	45.5
29	47	39	49	42	52	44.5	50	46.5	42	36.5	42	38	44	41	42	41
30	47	39	49	42	51.5	44.5	50	46.5	41	37	42.5	37.5	44.5	40	42	40
31									41	39	42	40	45.5	43	43	42

Appendix Bl - (continued)

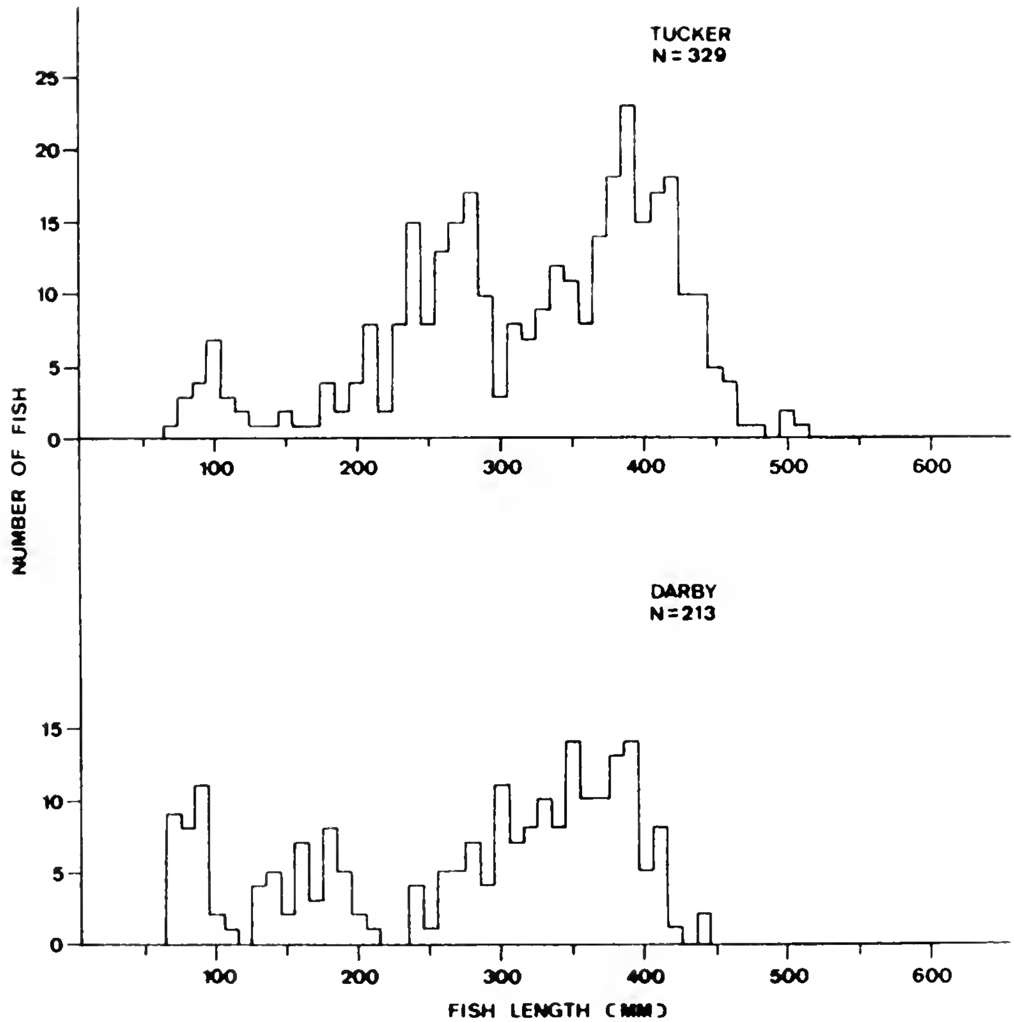
	NOVEMBER							
	Darby		Hamilton		Bell		Maclay	
Day	Max	Min	Max	Min	Max	Min	Max	Min
1	42	39	43	40	46.5	44	43	42
2	44.5	41	45.5	42	48	46.5	45	43
3	44.5	42	47	44	49	47	47	45
4	45	40	45.5	42	48	44	46.5	45
5	43	39	45	40.5	46.5	42.5	45	43
6	41	38	41	39.5	44	42	43	42
7	41	38.5	43	40	45	43	43.5	42
8	40	38	41.5	39.5	44.5	42.5	43	41.5
9	36.5	34	40	35.5	42	35	41.5	37
10	34	33	35	32.5	34	32.5	37	34
11	33	33	34	32	35	32.5	35	33
12	33	33	33.5	32	34.5	33	35	33
13	33	33	33.5	32	34	33	35	33
14	33.5	33	33.5	32	34.5	32.5	35	33
15	34	33	34	32	35	33	35.5	33
16	35	33.5	35	33			37	35.5
17	35	33	35	34			37	35
18	34.5	33	33	32			35	33
19	34	33	32.5	32			34.5	33
20	33.5	33	33	32			36	34
21	33	33	32.5	32			35	33
22	33	33	32	32			33	33
23	33	33	32	32				
24	33	33	32.5	32				
25	33	33	32.5	32				
26	33	33	33	32				
27	33	33	33	32				
28	33	32.5	32.5	32				
29	32.5	32.5	32	32				
30	32.5	32.5	32	32				
31								

APPENDIX C

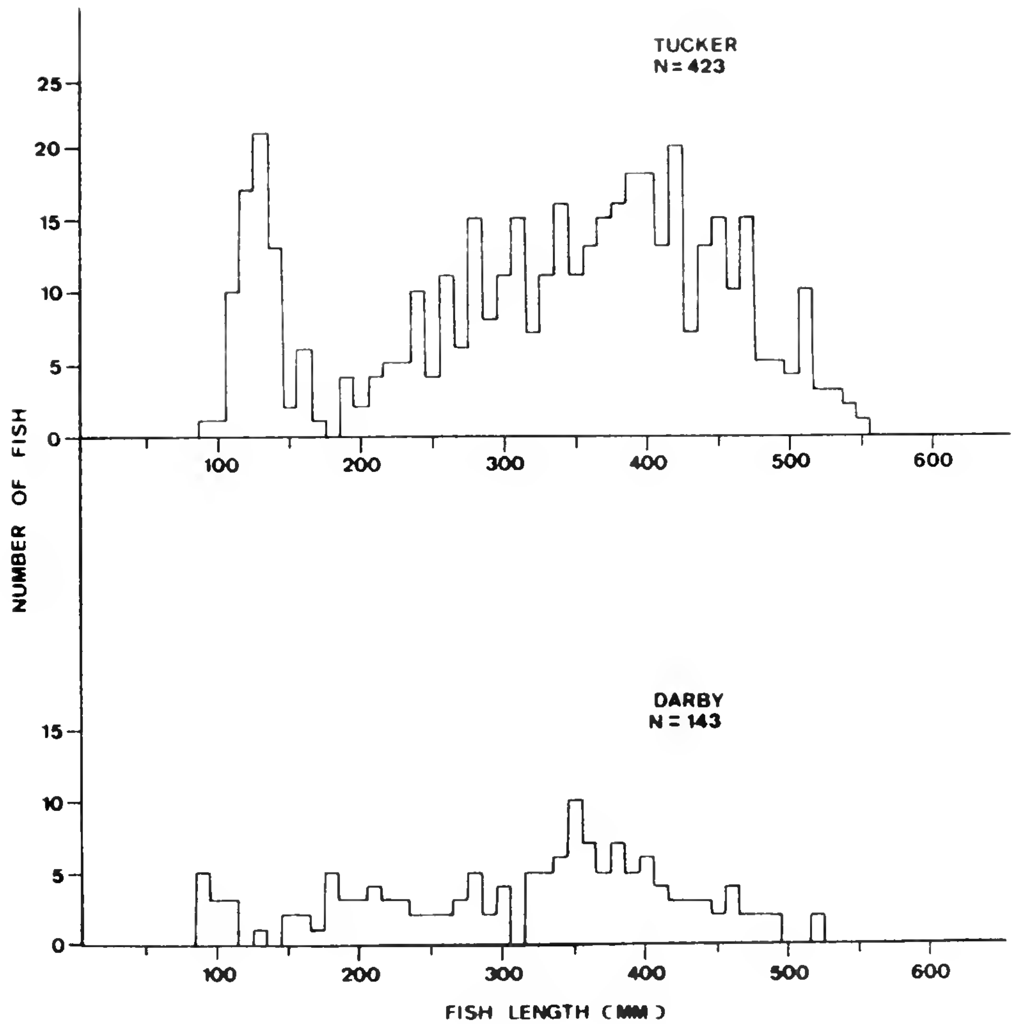
Parameters of Trout Populations

Appendix C1. Catch statistics for trout collected in the Darby and Tucker sections of the Bitterroot River during the spring of 1985. Range in parentheses.

Section	Species	Marked	Captured	Recaptured	Mean Length (MM)	Mean Weight (GM)
Darby	Rainbow Trout	119	106	9	279 (70-449)	318 (10-820)
	Brown Trout	89	67	10	318 (90-521)	431 (10-1690)
	Cutthroat Trout	5	3	0	317 (183-443)	416 (60-880)
	Brook Trout	10	19	0	163 (90-321)	66 (10-340)
	Bull Trout	6	4	2	318 (210-417)	390 (70-830)
Tucker (East Channel)	Rainbow Trout	89	64	9	314 (81-506)	396 (10-1140)
	Brown Trout	135	116	27	326 (110-556)	488 (10-1500)
	Cutthroat Trout	3	2	0	308 (278-378)	376 (260-660)
	Brook Trout	9	6	0	161 (101-307)	70 (10-290)
	Bull Trout	0	1	0	430 (--)	910 (—)
Tucker (West Channel)	Rainbow Trout	115	78	5	333 (78-513)	461 (10-1330)
	Brown Trout	90	126	15	341 (105-535)	485 (10-1330)
	Cutthroat Trout	0	2	0	292 (279-305)	300 (260-340)
	Brook Trout	1	4	0	206 (108-280)	128 (10-250)
	Bull Trout	1	0	0	215 (--)	90 (—)



Appendix C2. Length frequency distributions of rainbow trout collected in the Darby and Tucker sections during the spring of 1985.



Appendix C3. Length frequency distributions of brown trout collected in the Darby and Tucker sections during the spring of 1985.

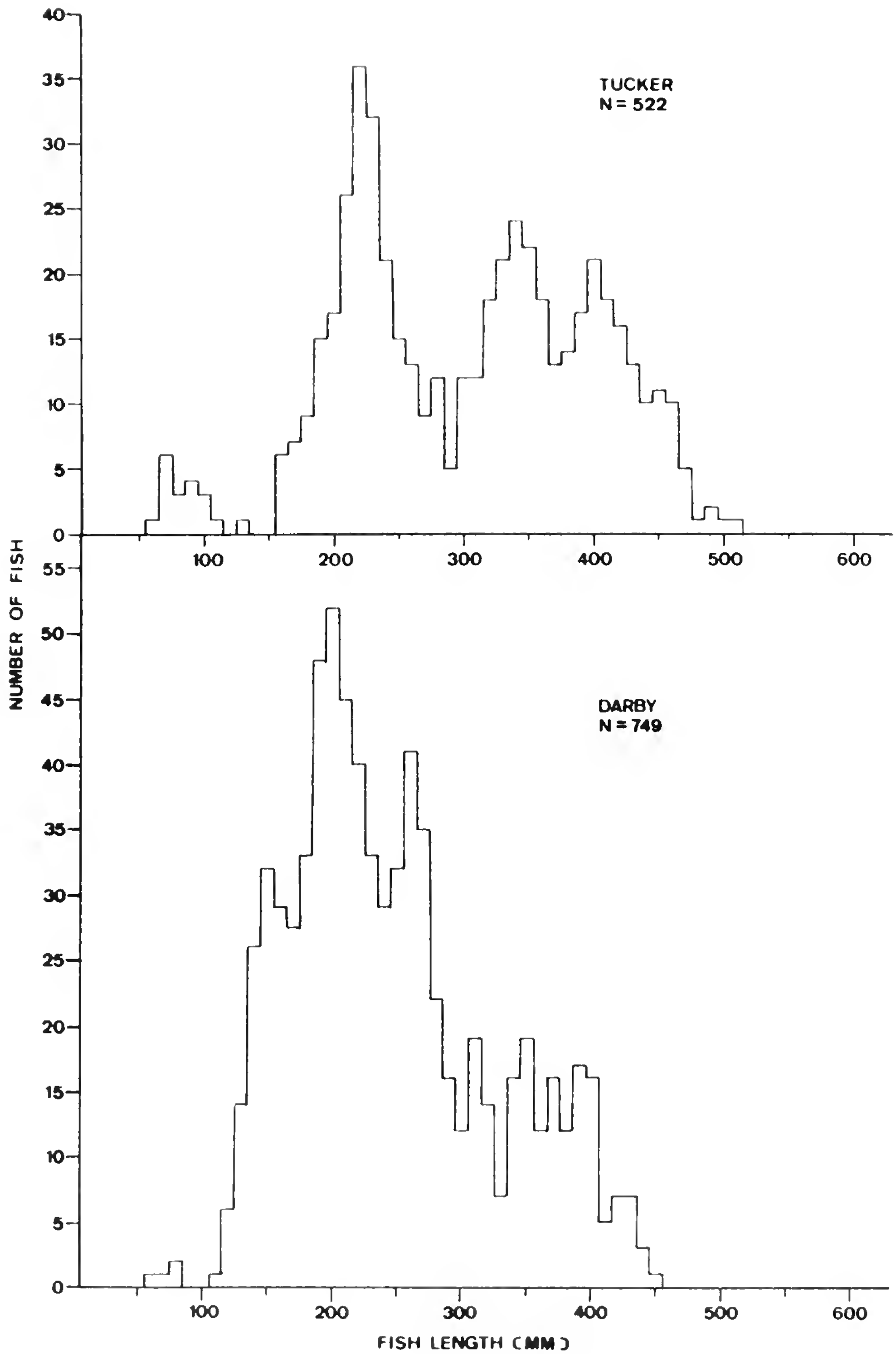
Appendix C4. Estimates of numbers (N), biomass and age structures of rainbow trout and brown trout in the study sections of the Bitterroot River obtained during the Spring, 1985. 80% confidence intervals in parentheses.

Section	Species	Age-Group	Per Kilometer N	Per Kilometer Biomass (kg)	Per Mile N	Per Mile Biomass (kg)
Darby	Rainbow Trout	I+	no estimate			
		II+[a]	2	0.33	3	0.54
		III+	21	5.58	33	8.98
		IV+ and older	52	25.02	83	40.27
		Total	75 (45-105)	30.94 (19.36-42.52)	119 (71-167)	49.76 (31.12-68.40)
	Brown Trout	I+	no estimate		no estimate	
		II+	no estimate		no estimate	
		III+	8	2.40	12	3.87
		IV+ & older	26	18.45	42	29.69
		TOTAL	34 (24-44)	20.85 (13.48-28.22)	54 (37-71)	33.56 (21.71-45.41)
Tucker (East Channel)	Rainbow Trout	I+	no estimate		no estimate	
		II+[a]	5	0.94	8	1.51
		III+	22	6.06	36	9.75
		IV+ & older	22	13.11	35	21.10
		TOTAL	49 (33-65)	20.11 (14.13-26.09)	79 (54-104)	32.36 (22.74-41.98)
	Brown Trout	I+	no estimate		no estimate	
		II+[a]	9	2.22	14	3.58
		III+	15	6.77	24	10.89
		IV+ & older	17	14.12	27	22.73
		TOTAL	41 (32-50)	23.11 (18.97-27.25)	65 (50-80)	37.20 (30.54-43.86)
Tucker (West Channel)	Rainbow Trout	I+	no estimate		no estimate	
		II+[a]	5	0.85	8	1.36
		III+	21	5.16	33	8.31
		IV+ & older	84	52.07	135	83.78
			110 (61-159)	58.08 (32.18-83.98)	176 (98-254)	93.45 (51.78-135.12)
	Brown Trout	I+	no estimate		no estimate	
		II+[a]	3	0.63	4	1.01
		III+	16	6.07	25	9.77
		IV+ & older	31	22.21	51	35.74
		TOTAL	50 (38-62)	28.91 (22.12-35.70)	80 (60-100)	46.52 (35.59-57.45)
Tucker	Rainbow Trout	TOTAL	159 (107-211)	78.19 (51.61-104.77)	255 (173-337)	125.81 (83.04-168.58)
	Brown Trout	TOTAL	91 (76-106)	52.02 (44.07-59.97)	145 (120-170)	83.72 (70.92-96.52)

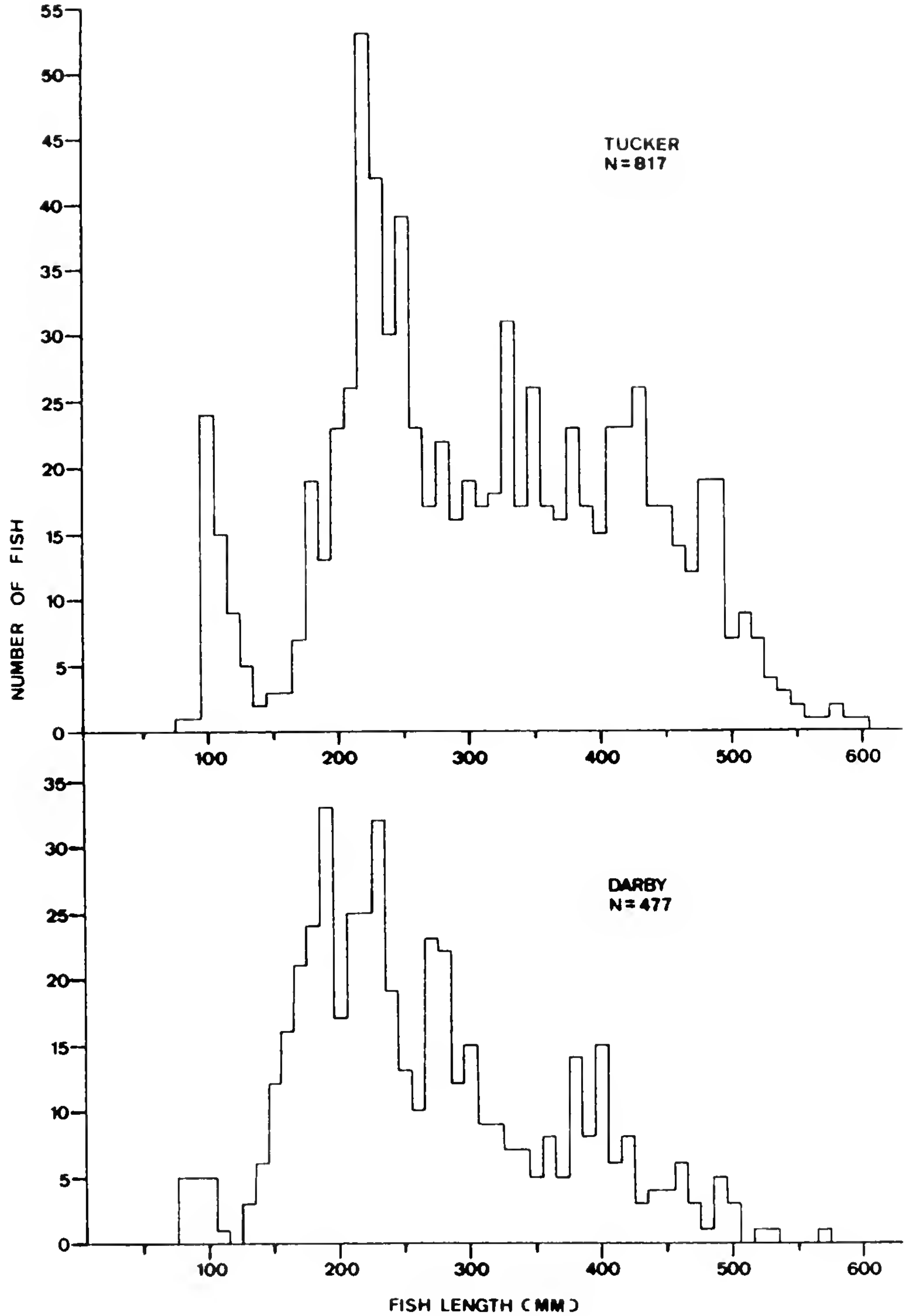
[a] partial estimate

Appendix C5. Catch statistics for trout collected in the Darby, Tucker and Poker Sections during the fall of 1985. Range in parentheses.

Section	Species	Marked	Captured	Recaptured	Mean Length (mm)	Mean Weight (gm)
Darby	Rainbow trout	475	282	22	239 (58-444)	199 (5-1080)
	Brown trout	319	189	30	258 (70-565)	279 (5-2210)
	Cutthroat trout	29	21	4	274 (115-376)	246 (10-600)
	Brook trout	28	4	0	192 (80-368)	107 (5-540)
	Bull trout	5	6	0	279 (165-402)	246 (50-650)
Tucker (East Channel)	Rainbow trout	141	112	10	309 (56-505)	429 (5-1510)
	Brown trout	229	187	39	312 (83-667)	468 (10-3120)
	Cutthroat trout	3	5	0	310 (195-430)	416 (100-770)
	Brook trout	10	1	0	214 (107-311)	155 (10-370)
Tucker (West Channel)	Rainbow trout	196	94	14	286 (60-463)	320 (5-1060)
	Brown trout	270	234	57	302 (70-588)	408 (5-2500)
	Cutthroat trout	1	3	0	287 (243-305)	265 (90-350)
Poker Joe	Rainbow trout	202	188	25	320 (75-495)	390 (10-1170)
	Brown trout	40	29	4	288 (112-447)	324 (10-1090)
	Cutthroat trout	1	6	0	322 (271-359)	368 (250-480)
	Brook trout	1	0	0	253 (---)	220 (---)



Appendix C6. Length frequency distributions of rainbow trout collected in the Darby and Tucker sections during the fall of 1985.



Appendix C7. Length frequency distributions of brown trout collected in the Darby and Tucker sections during the fall of 1985.

Appendix C8. Mean total length (TL) at time of capture and back-calculated mean total length at age for rainbow trout in study sections of the Bitterroot River during the Fall, 1984.

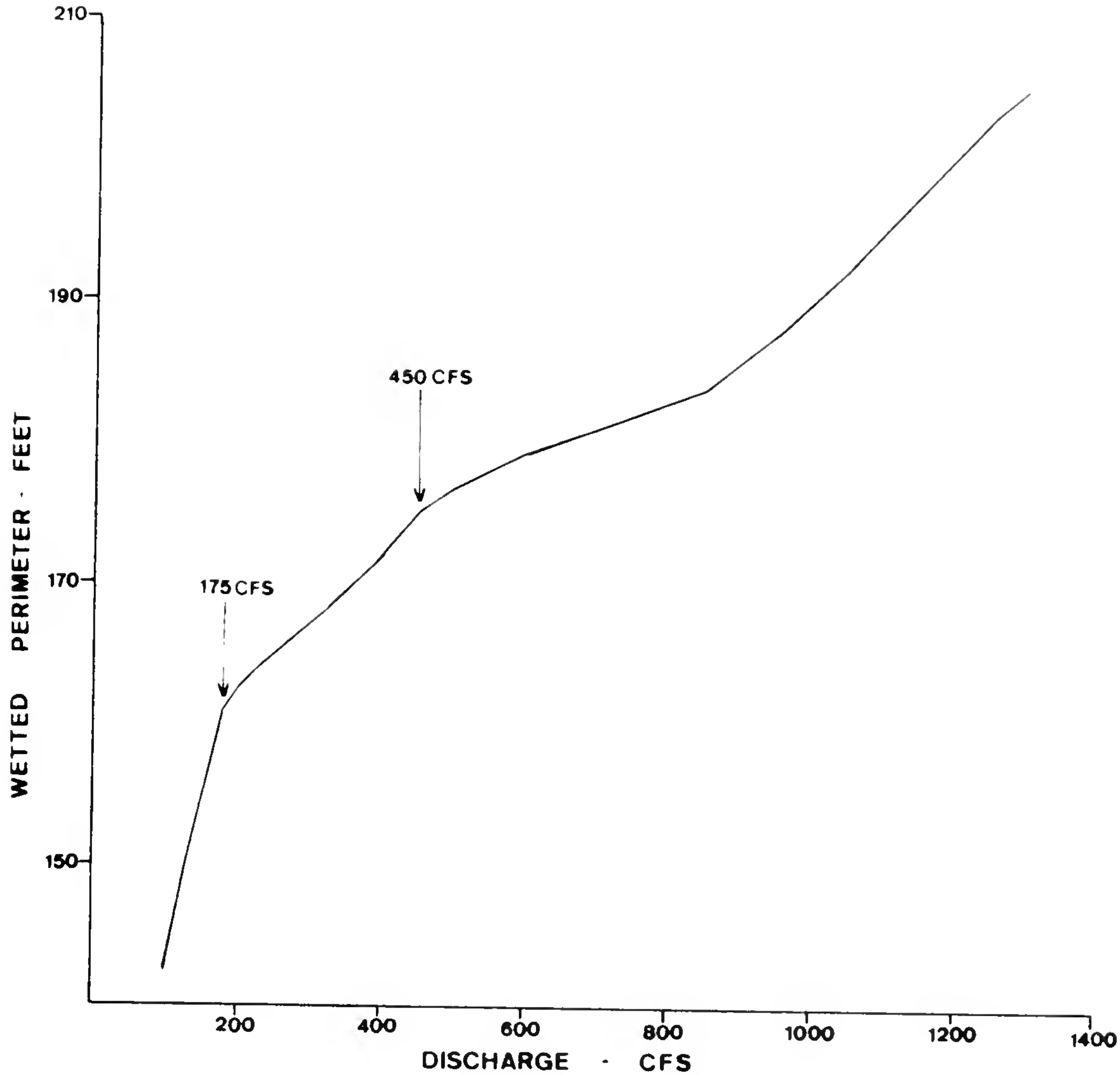
Section	Age group	N	Mean TL at capture (mm)	Calculated Length (mm) at Age					
				I	II	III	IV	V	VI
Darby	0+	7	75						
	I+	121	162	79					
	II+	66	242	85	164				
	III+	68	312	78	156	255			
	IV+	43	369	82	161	258	327		
	V+	12	402	76	159	255	325	370	
	VI+	1	392	75	142	243	290	331	372
Mean back-calculated length (mm)				80	160	256	326	367	372
Mean increment of back-calculated length (mm)				80	80	96	70	41	5
Tucker (E. Channel)	0+	4	91						
	I+	43	200	82					
	II+	59	236	88	172				
	III+	39	336	91	193	278			
	IV+	30	391	91	188	271	339		
	V+	21	429	92	178	258	332	388	
	VI+	1	475	105	212	272	356	420	458
Mean back-calculated length (mm)				88	182	271	337	389	458
Mean increment of back-calculated length (mm)				88	94	89	66	52	69
Tucker (W. Channel)	0+	10	85						
	I+	55	177	77					
	II+	62	220	79	154				
	III+	25	320	83	191	274			
	IV+	30	380	87	185	274	337		
	V+	7	425	91	208	279	344	393	
	VI+	1	437	81	133	277	322	390	410
Mean back-calculated length (mm)				81	171	275	338	393	410
Mean increment of back-calculated length (mm)				81	90	104	63	55	17
Pooled Total	0+	21	83						
	I+	219	173	79					
	II+	187	233	84	163				
	III+	132	321	82	174	265			
	IV+	103	379	86	176	266	333		
	V+	40	420	87	177	261	332	383	
	VI+	3	435	82	162	264	323	380	413
Mean back-calculated length (mm)				82	170	265	333	383	413
Mean increment of back-calculated length (mm)				82	88	95	68	50	30

Appendix C9. Mean total length (TL) at time of capture and back-calculated mean total length at age for brown trout in study sections of the Bitterroot River during the Fall, 1984.

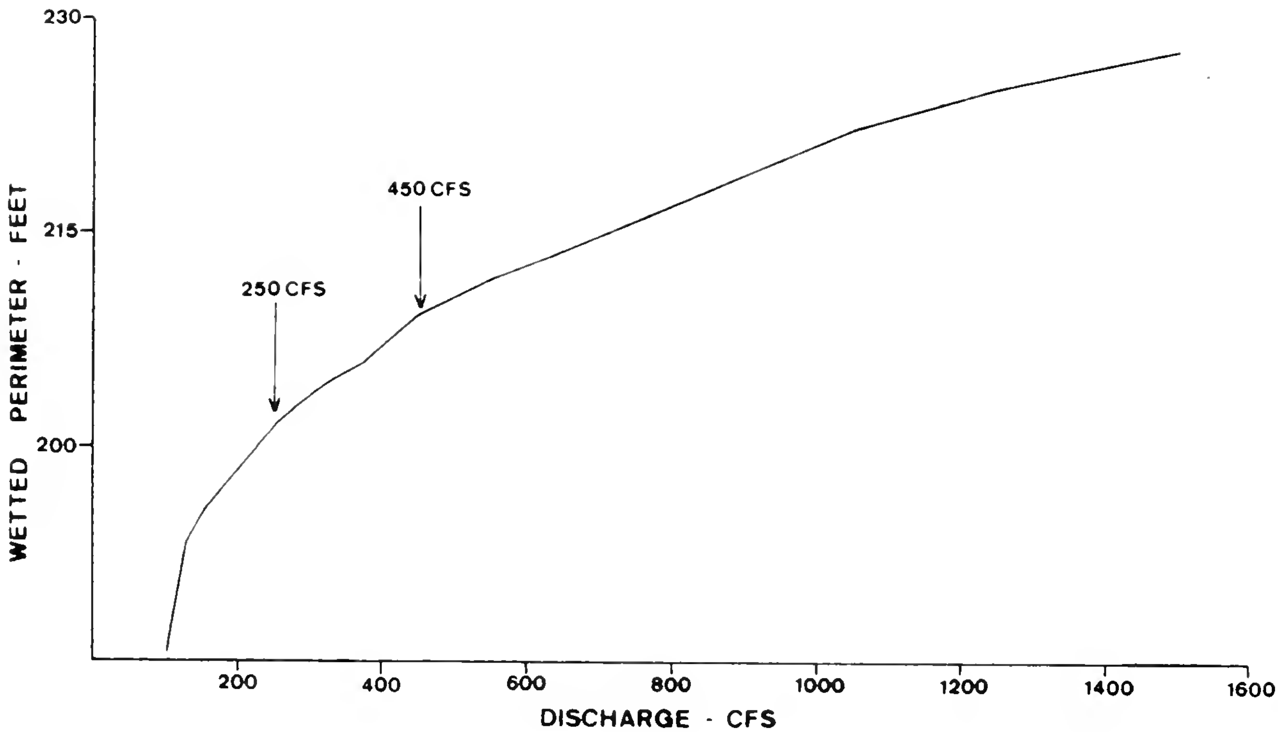
Section	Age group	N	Mean TL at capture (mm)	Calculated Length (mm) at Age I	II	III	IV	V	VI	VII
Darby	0+	19	89							
	I+	98	171	90						
	II+	74	249	86	177					
	III+	46	340	96	196	290				
	IV+	19	403	97	209	292	359			
	V+	17	453	106	204	299	368	417		
	VI+	3	453	85	162	265	328	394	424	
Mean back-calculated length (mm)				92	189	292	361	413	424	
Mean increment of back-calculated length (mm)				92	97	103	69	52	11	
Tucker (E. Channel)	0+	38	109							
	I+	55	206	102						
	II+	55	261	99	193					
	III+	46	345	105	196	285				
	IV+	23	419	121	210	305	370			
	V+	12	460	114	188	288	362	415		
	VI+	4	498	117	210	300	368	425	465	
	VII+	1	529	121	258	326	389	425	467	506
Mean back-calculated length (mm)				105	197	292	368	418	465	506
Mean increment of back-calculated length (mm)				105	92	95	76	50	47	41
Tucker (W. Channel)	0+	15	106							
	I+	66	203	94						
	II+	66	265	94	184					
	III+	55	356	101	213	302				
	IV+	30	421	107	213	306	375			
	V+	12	481	118	232	328	394	440		
	VI+	2	516	111	215	298	347	421	477	
Mean back-calculated length (mm)				99	203	306	379	437	477	
Mean increment of back-calculated length (mm)				99	104	103	73	58	40	
Pooled Total	0+	72	103							
	I+	219	189	94						
	II+	195	258	91	184					
	III+	147	348	101	202	293				
	IV+	72	415	109	211	302	369			
	V+	41	463	112	207	304	374	423		
	VI+	9	487	105	195	288	350	414	454	
	VII+	1	529	121	258	326	389	425	467	506
Mean back-calculated length (mm)				98	196	297	370	421	455	506
Mean increment of back-calculated length (mm)				98	98	101	73	51	34	51

APPENDIX D

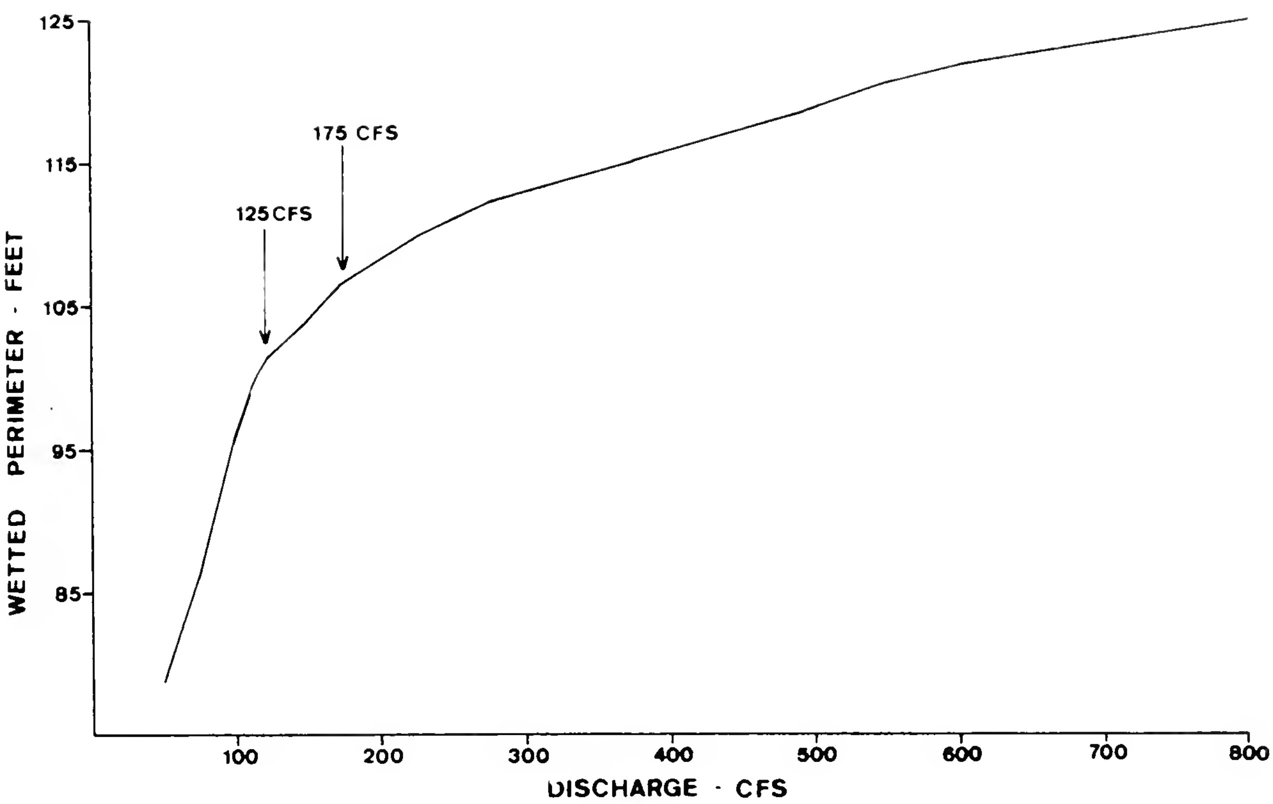
Discharge-Wetted Perimeter Relationships



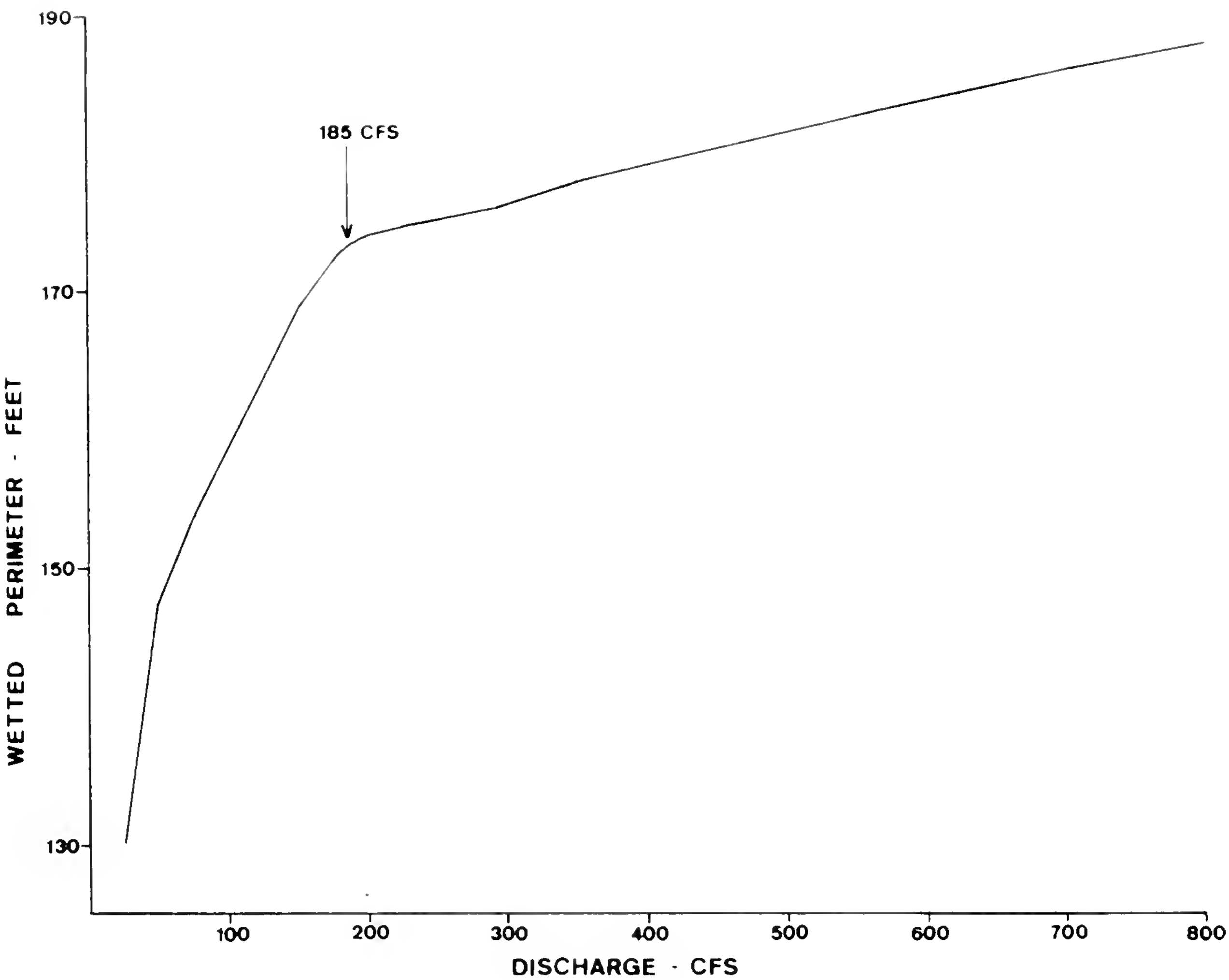
Appendix D1. Wetted perimeter-discharge relationship for a composite of 3 cross sections of a riffle near Hamilton.



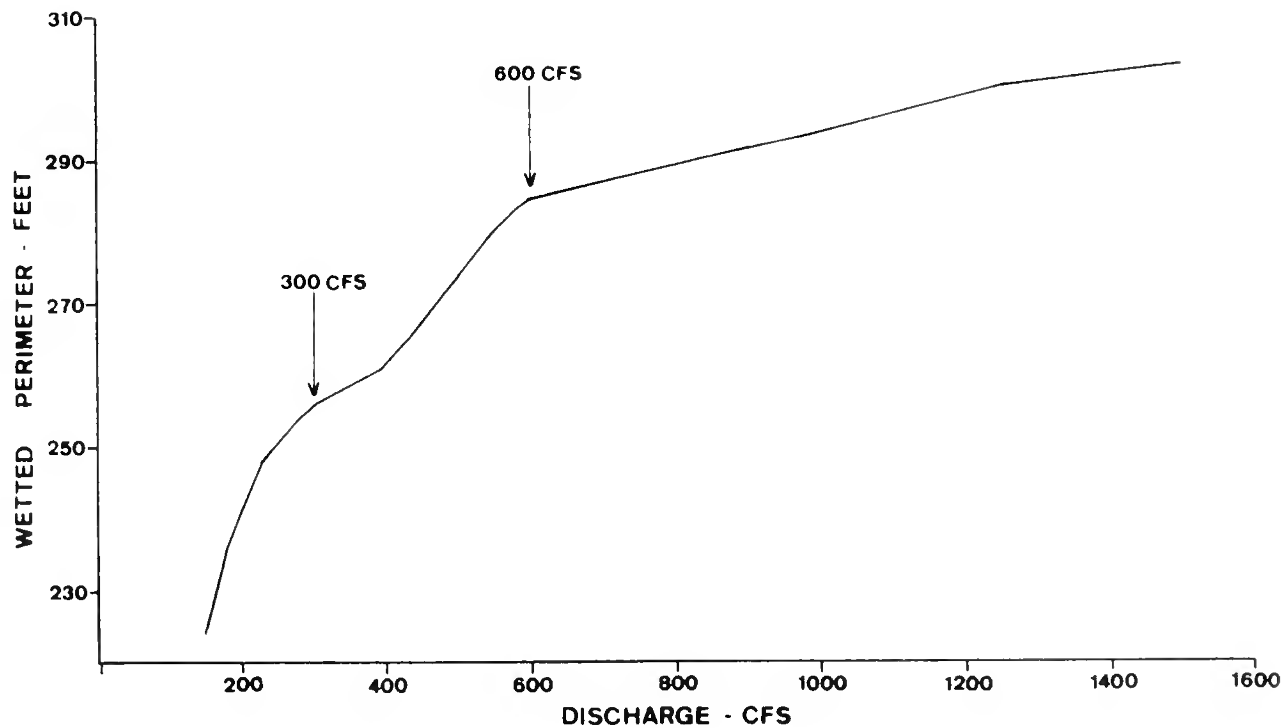
Appendix D2. Wetted perimeter-discharge relationship for a composite of 3 cross sections of a riffle near the mouth of Blodgett Creek.



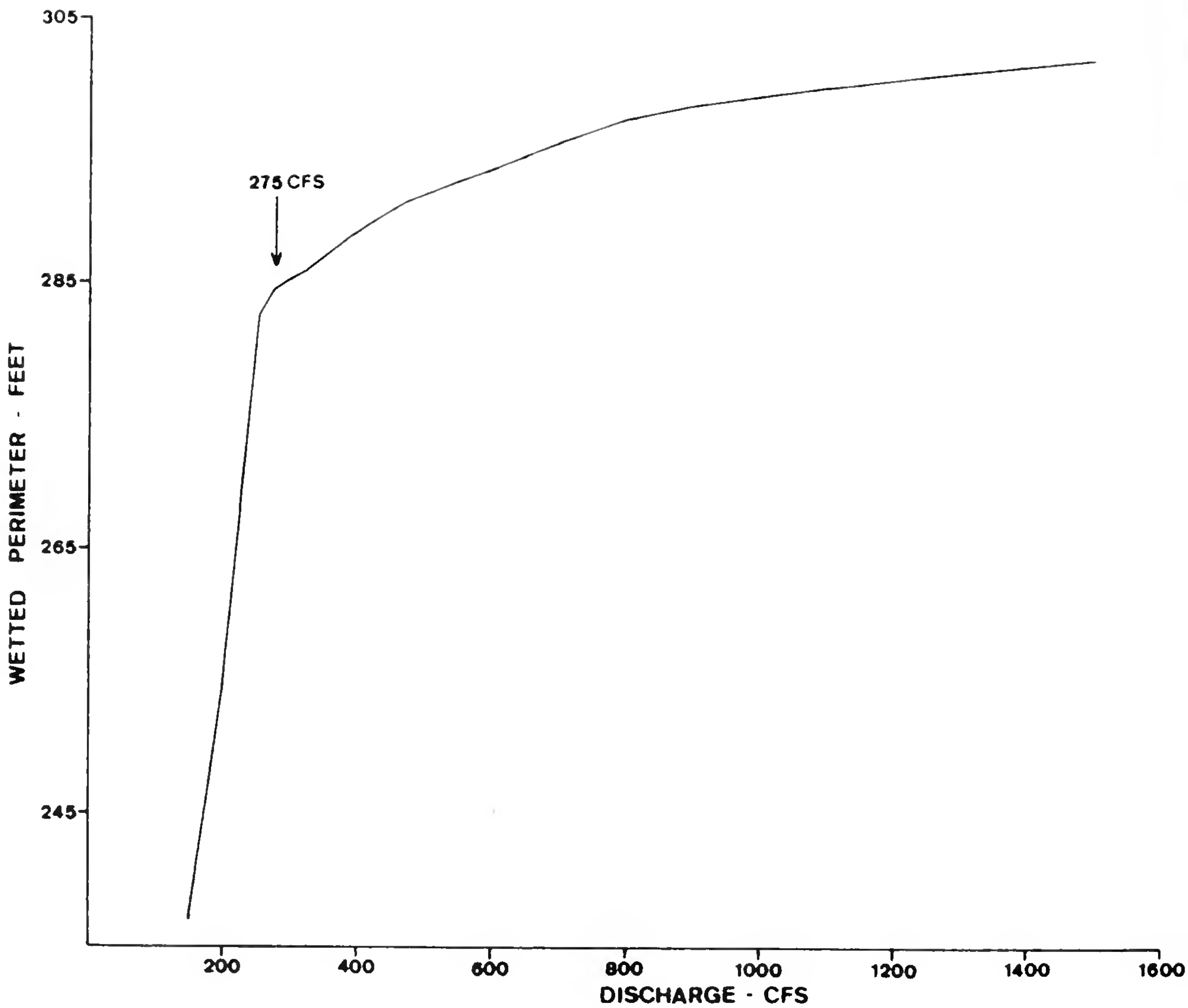
Appendix D3. Wetted perimeter-discharge relationship for a composite of 3 cross sections of a riffle in the east channel of the Tucker section.



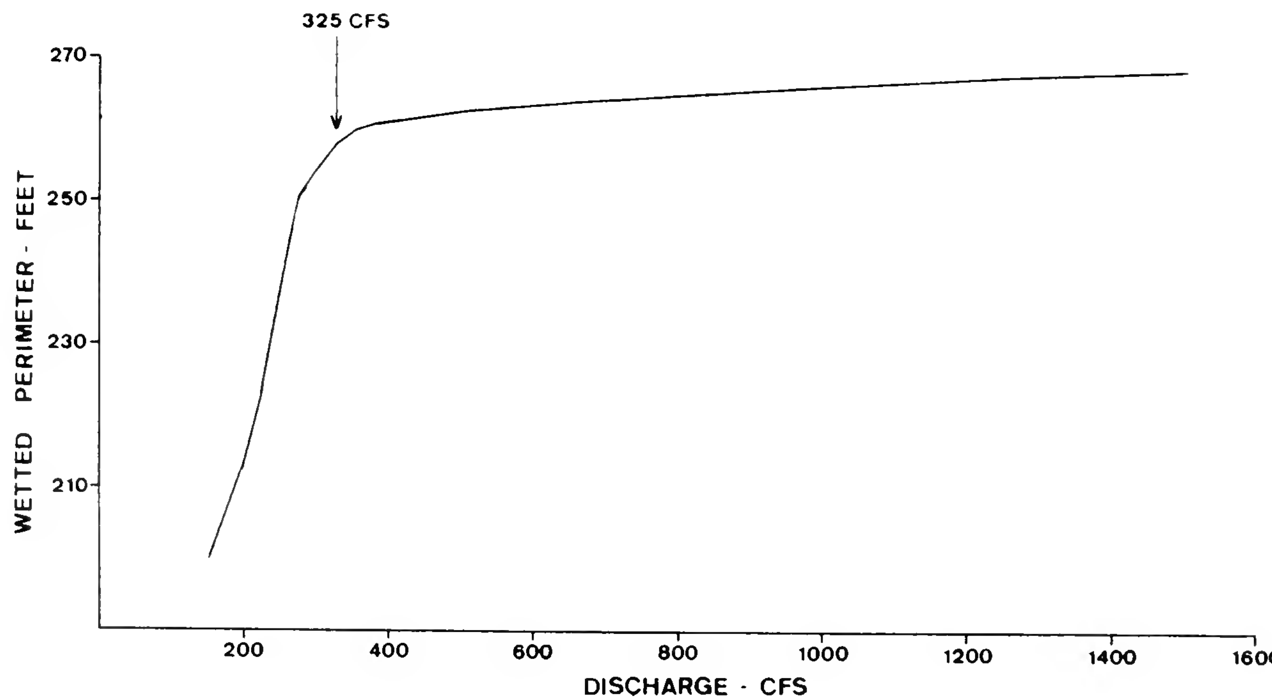
Appendix D4. Wetted perimeter-discharge relationship for a composite of 3 cross sections of a riffle in the west channel of the Tucker section.



Appendix D5. Wetted perimeter-discharge relationship for a composite of 3 cross sections of a riffle near Stevensville.



Appendix D6. Wetted perimeter-discharge relationship for a composite of 3 cross sections of a riffle near the Lee Metcalf Wildlife Refuge.



Appendix D7. Wetted perimeter-discharge relationship for a composite of 3 cross sections of a riffle near the mouth of Bass Creek.